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THE CRITICAL CHALLENGES FACING AGRICULTURAL RESEARCH

JOINT HEARING

BEFORE THE

SUBCOMMITTEE ON AGRICULTURAL RESEARCH AND GENERAL LEGISLATION

OF THE

COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY
UNITED STATES SENATE

AND THE

SUBCOMMITTEE ON DEPARTMENT OPERATIONS, RESEARCH, AND FOREIGN AGRICULTURE

OF THE

COMMITTEE ON AGRICULTURE
HOUSE OF REPRESENTATIVES

ONE HUNDREDTH CONGRESS

SECOND SESSION

ON

THE STRUCTURE AND FUNCTION OF THE AGRICULTURAL RESEARCH SYSTEM

SEPTEMBER 29, 1988

Serial No. 100-111
House Committee on Agriculture

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THE CRITICAL CHALLENGES FACING AGRICULTURAL RESEARCH

THURSDAY, SEPTEMBER 29, 1988

U.S. SENATE,
SUBCOMMITTEE ON AGRICULTURAL RESEARCH
AND GENERAL LEGISLATION OF THE
COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY,
Washington, DC.

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON DEPARTMENT OPERATIONS,
RESEARCH, AND FOREIGN AGRICULTURE OF THE
COMMITTEE ON AGRICULTURE,
Washington, DC.

The subcommittees met, pursuant to notice, at 10:10 a.m., in room SR-332, Russell Senate Office Building, Hon. Kent Conrad (chairman of the subcommittee) presiding, together with Hon. George E. Brown, Jr. (chairman of the Subcommittee on Department Operations, Research, and Foreign Agriculture).

Present or submitting a statement: Senators Conrad and Bond; and Representatives George E. Brown, Jr., and Pat Roberts.

Also submitting a prepared statement: Senator Pete V. Domenici.

STATEMENT OF HON. KENT CONRAD, A U.S. SENATOR FROM NORTH DAKOTA

Senator CONRAD. This hearing will come to order before the Senate Subcommittee on Agricultural Research and General Legislation and the House Subcommittee on Department Operations, Research, and Foreign Agriculture.

Good morning, and welcome to this joint hearing on the Critical Challenges Facing Agricultural Research.

I feel very honored today to have such a distinguished panel of witnesses, and such a distinguished co-chair, my colleague, Congressman George Brown, who is chairman of the House Subcommittee on Department Operations, Research, and Foreign Agriculture.

This is the first of a series of hearings on the structure and function of the agricultural research system. The purpose of these hearings is to evaluate our current agricultural research system and determine whether it is ready to meet the challenges faced by American agriculture in the future. A thorough evaluation is needed to prepare us for the reauthorization of the research title of the 1990 farm bill.

As we look toward the next farm bill, we are looking at a changing agricultural situation. The role of agriculture is no longer to simply produce as much as possible to keep up with the world's demand for food and fiber. Today, the United States is fighting to retain its market share of agricultural exports against increasingly efficient competitors. The success of the agricultural industry no longer depends just on production ability—it also requires increased profits from the market and international competitiveness.

Commodity prices are low; surpluses are common; farmers and agricultural businesses are facing economic hardship; and concerns about the effect of our production practices on the environment and our health are growing. There is an increasing need to reduce the cost of production and to emphasize economic yields rather than just production yields. In addition, our agricultural industry must actively market our products. That means finding new markets and uses for our commodities and tailoring our products to the needs of domestic and foreign consumers. I believe that agricultural research plays a vital role in ensuring a successful and profitable agricultural industry in this new age.

Yet there is real concern that the public and private sector agricultural research system is not responding to the realities of this new age. Some assert that USDA is still focusing most of its research effort on increasing agricultural productivity, rather than new uses for commodities, and new production technologies which are cheaper and environmentally safe.

The purpose of our hearing today is to examine the current problems within our research system, and the possible options to solve them. What are we doing right? What needs to be changed? Is the system responding to changing needs of farmers? Are we using new technology, such as biotechnology, to full advantage to keep ahead of our competitors?

Is the current organization of USDA's research programs—the Agricultural Research Service, the Cooperative State Research Service, and the Extension Service—effective? Has the Federal Government established appropriate research priorities so that scarce research dollars are used to meet important research needs? What is the most effective funding mechanism? What are the roles of the public and private sectors in conducting agricultural research? Is there effective coordination of research within the public sector, and between the public and private sectors? Is there a need for increased interdisciplinary research and more involvement of the users of agricultural research in designing research projects?

These and many other questions must be discussed as we examine our current agricultural research system. I look forward to a lively roundtable discussion among our witnesses and colleagues about the problems and strengths of our current research system. I also look forward to working with my counterpart in the House, Congressman Brown, as we proceed with our examination of the research system. His knowledge, experience and wit will be invaluable in this important endeavor.

[The prepared statements of Senator Bond and Representatives Brown and Roberts follow:]

STATEMENT BY SENATOR CHRISTOPHER S. BOND (R-MO)
BEFORE THE SENATE COMMITTEE ON AGRICULTURE, NUTRITION AND FORESTRY
SUBCOMMITTEE ON AGRICULTURAL RESEARCH AND GENERAL LEGISLATION AND
THE HOUSE SUBCOMMITTEE ON DEPARTMENT OPERATIONS, RESEARCH, AND
FOREIGN AGRICULTURE
THURSDAY, SEPTEMBER 29, 1988, 10:00 A.M.

As we move towards consideration of the 1990 farm bill, it is essential that we conduct thorough reviews of the major sectors of American agriculture. I commend my distinguished colleagues, Senator Conrad and Congressman Brown, for recognizing the importance of this process and applaud their plans to hold a series of hearings on the "Critical Challenges Facing American Agriculture."

Although not a member of the Subcommittee on Agricultural Research and General Legislation, I share the Chairmens' interest in agricultural research. There is no doubt that the structure of American agriculture continues to evolve from the labor intensive industry known by our ancestors to the technical, capital intensive industry we see today. Although land prices represent significant capital outlays, other outlays for farm equipment and interest on operating loans continue to push per unit production costs higher.

Over the past decade, the structure of international agriculture has also changed dramatically. Many countries which imported commodities are now self-sufficient or actually net exporters. Many countries have promoted agricultural exports to generate foreign currency in attempts to meet loan obligations. All in all, U.S. farmers must now compete in a very sophisticated world market comprised of many, many sellers. Our competitors have become very efficient, maximizing the return from each unit produced. No longer can the U.S. have a "fence row to fence row" mentality.

In this new era, production agriculture will be forced to lower operating costs while at the same time comply with more stringent environmental requirements. It seems that we have shifted from short-term policies designed to maximize production to longer-term programs designed to sustain the productivity of our fragile resources.

The research title of the next farm bill will have to address a renewed commitment to the development of new industrial crops and new uses for existing crops. Biotechnology and genetic engineering will play an increased role in agriculture as techniques are developed to ensure environmental and human safety. Specific environmental issues such as Conservation Compliance and ground water will need to be thoroughly researched.

Finally, I believe the Chairmen are providing an important service to our citizens by reviewing existing research programs to ensure that current programs and policies are not inconsistent with our objectives or are simply duplicative. As we are all aware, research priorities cannot be changed overnight -- the Subcommittees' efforts will be an important step in leading us toward the turn of the century.

OPENING STATEMENT OF

CONGRESSMAN GEORGE E. BROWN, JR.

JOINT HOUSE-SENATE HEARINGS ON AGRICULTURE RESEARCH

SEPTEMBER 29, 1988

It is a pleasure to be here this morning with our Senate counterparts to conduct this oversight of our agricultural research system and its future directions. These hearings come after a number of separate deliberations about specific areas of research needs, such as the needs to develop alternative production opportunities for farmers. Today's hearings should put these specific areas in a broader context and help prepare us for the start of deliberations on the 1990 Farm Bill.

These hearings are somewhat unique. We do not often hold joint hearings between the House and the Senate, but we should conduct more of them. The issues facing our respective committees are the same and, while our approaches to those issues may differ, we should develop those approaches from a common base of understanding. It is my hope that as we start our work on the 1990 Farm Bill that we can conduct more joint hearings. Should I be in my present position in the next Congress, I hope to follow this hearing with additional joint hearings on agricultural research.

We have assembled a distinguished panel of witnesses today and I look forward to hearing from them.

STATEMENT OF THE HONORABLE PAT ROBERTS
JOINT HEARING BY HOUSE AND SENATE SUBCOMMITTEES ON AGRICULTURAL RESEARCH
SEPTEMBER 29, 1988

I am pleased to note the high level of distinction represented by our four witnesses. This hearing is long overdue, and I want to commend the leadership of both Subcommittees for endeavoring to establish a common basis of information and dialogue between the House and Senate on agricultural research issues.

For too long the parochialism of Congressional politics has infected agricultural research. The Federal role in agricultural research demands clarity: we need firmly established national research goals (based on well thought out priorities), and clear lines of purpose and accountability by our research institutions.

Agricultural research will figure prominently in the 1990 Farm bill. Increasingly, in Congress and rural America doubts arise regarding the long term viability of this nation as an agricultural exporter. We have to deal with those doubts, and long term agricultural research is the guarantor of a properous and stable farm economy. This country's advantage in agricultural production is not founded on low input, low cost labor farming. We rely on high tech, capital intensive farming and we must assure the adequacy of agricultural research to respond to present and future needs; otherwise, we simply undercut the ability of future generations to make a living in farming.

We can see now where research has not prepared us well for certain challenges. For example, the pendulum of public concern over environmental issues is swinging back to the days of the early and middle Seventies. As a consequence, agriculture must "clean" itself up. People want reduced pesticide residues, clean groundwater, less soil erosion, and the harmonization of farming practices with the needs of wildlife. Regardless of merit, the broader public will eventually receive some satisfaction to their concerns -- either through legislation or regulation. Farming costs will increase and some, perhaps many, farmers will have to quit their livilihoods. I certainly don't enjoy those prospects, and I believe we must direct our research potential towards the development of environmentally benign cultural practices and chemicals. I hope Congress and the research community is up to the task.

Senator CONRAD. Let me now introduce our witnesses: Dr. Theodore Hullar, who is Chairman of the Board on Agriculture of the National Research Council, and chancellor of the University of California at Davis; Dr. William Marshall, president, Pioneer Hi-Bred International, Inc., Microbial Genetics Division; Dr. Mary-Dell Chilton, the executive director of agricultural biotechnology at CIBA-GEIGY, and governing board member of the National Academy of Sciences Council; and Dr. Peter Day, the director of the Center for Agricultural Molecular Biology at Rutgers University. Thank you all for coming to testify today. We very much appreciate that, and without further ado, I think we should start.

Chairman Brown will be here momentarily, and I think he would prefer that we begin so that we do not get behind schedule. So with that, I would turn to Dr. Marshall, again, the president of Pioneer Hi-Bred International, Inc., Microbial Genetics Division. Welcome.

STATEMENT OF WILLIAM E. MARSHALL, PRESIDENT, PIONEER HI-BRED INTERNATIONAL, INC., MICROBIAL GENETICS DIVISION, FORMER CHAIR OF USDA USERS ADVISORY BOARD, JOHNSTON, IA

Dr. MARSHALL. Thank you.

Mr. Chairman, my name is William Marshall, and I am president of the Microbial Genetics Division of Pioneer Hi-Bred International, Inc. In 1982 and in 1983 I served as a member of the Grace Commission assigned to study the cost-effectiveness of funding of agricultural research by the USDA. For the past 5 years, until February of this year, I have served as Chairman of the National Agricultural Research and Extension Users Advisory Board.

My personal field of research is biotechnology, not with the release of genetically engineered organisms, but rather with the commercialization of the broader application of molecular biology, for example, the use of natural microorganisms, biorational pesticides, vaccines, et cetera.

The world market for commodities has become fiercely competitive. As lower price commodities enter the world markets, we have but three choices, as I see it. One, increase our subsidies or decrease our production; two, decrease our costs of production; or three, increase the added value of our products.

As a taxpayer and scientist, I prefer options two and three, and so do most people involved with agricultural research. That is to decrease our costs of production and increase the added value of our products.

Herein lies the problem. Agricultural research in both our public and private sectors has spent 100 years developing technologies that increase yields without much regard for their costs. A system that has served the world so well is difficult to change, and to make matters worse, the solutions lie outside the system.

As we unravel the secrets of cell biology, we can see the possibility to dramatically reduce production costs. Slowly, but surely, the breadth of agricultural research has expanded during the last 10 years.

For example, only one-half of Uncle Sam's funding for agriculture research is now funneled through the U.S. Department of Agriculture. And 40 percent of all the active agricultural scientists and engineers earned Ph.D. degrees outside applied agricultural disciplines. These fields include biochemistry, bacteriology, genetics, molecular biology, plant and animal physiology, zoology, botany, economics, ecology, sociology, plant pathology, entomology, and other sciences.

The Federal Government is spreading its investment in agricultural research across all government agencies. Generally speaking, there is adequate growth of Federal support for agricultural research in the United States in my opinion.

The issue is that most of our colleges of agriculture have not been part of the growth because they do not have fundamental science departments within the college. And that is where both Federal and private money is going these days.

In my opinion, the answer to the funding problem of our colleges of agriculture is not: making agriculture more attractive to students, or centralizing control of their research agenda, or emphasizing the importance of applied faculty research, or switching to nonfarming areas, or even more funding.

What not to do? Do not tamper with the competitive grants or the peer-review system. Do not believe that biotechnology is a passing fad. When you hear the phrase "agricultural research," do not just think of our land-grant colleges of agriculture.

I would ask that when you hear the phrase "agriculture research in the public sector" you think not only of the 50 percent being done in our colleges of agriculture, but also the other 50 percent being conducted in fundamental departments of our universities being supported by NSF, NIH, DOE, and other agencies. A holistic view is a more accurate view, and you are responsible for all Federal funding of all ag research, not just that portion funneled through the USDA.

Ask the next administration to account for agricultural research spending across all Federal agencies, not just through the USDA. Put a provision in the next farm bill that places a higher priority on any Federal research proposal that is a collaboration between an applied ag researcher in a college of agriculture and a scientist in a fundamental department.

Causing these two forces to join together will have an enormous, positive effect in the foreseeable future on our productivity and profitability and also on the funding of our colleges of agriculture. The strength of our Nation is in both scientific discovery and application. Technology transfer needs to be hastened between basic and applied research.

Also, education in agriculture needs to be toughened, both in entrance requirements as well as in the curricula. To be competitive in a tougher world market, we can no longer afford agriculture its special status of academic mediocrity.

Likewise, the faculty in extension need to be better trained in the fundamental sciences to act as the third leg of the stool, with researcher and farmer.

In summary, the goals of agricultural research need to include cheaper biological inputs to support lower commodity prices. The strategy needed to accomplish this requires strong research coordination between the fundamental sciences and the traditional applied ag sciences. The extension programs will provide new practical knowledge for old and new clients.

Thank you for the privilege of addressing you.

Senator CONRAD. Thank you. We appreciate your participation.

[The prepared statement of Dr. Marshall follows:]

STATEMENT OF DR. WILLIAM E. MARSHALL, PRESIDENT PIONEER HI-BRED INTERNATIONAL, INC., MICROBIAL GENETICS DIVISION

Mr. Chairman, my name is William Marshall and I am President of the Microbial Genetics Division of Pioneer Hi-Bred International, Inc. In 1982 and 1983 I served as a member of the Grace Commission assigned to study the cost-effectiveness of funding of agricultural research by the USDA. For the past five (5) years I have served as Chairman of the National Agricultural Research and Extension Users Advisory Board. That 25-member Board, drawn from the private sector, provides advice to congressional committees and the Secretary of Agriculture through written reports as mandated by the 1977 Farm Bill.

The Advisory Board has the responsibility for:

(A) reviewing the policies, plans, and goals of programs within the Department of Agriculture involving the food and agricultural sciences, and related programs in other Federal and State departments and agencies and in the colleges and universities developed by the Secretary under this title;

(B) reviewing and assessing the extent of agricultural research and extension being conducted by private foundations and businesses, and the relationships of such research and extension to federally supported agricultural research and extension;

(C) reviewing and providing consultation to the Secretary on national policies, priorities, and strategies for agricultural research and extension for both the short and long term;

(D) assessing the overall adequacy of, and making recommendations to the Secretary with regard to, the distribution of resources and allocation of funds authorized by this title.

I appreciate the opportunity to present my views to you today. These views are derived largely from these first-hand experiences, the literature and discussions over the past 6 years. For better or worse, I had no pre-conceived notions about the structure or funding of agricultural research prior to the 1980s.

My personal field of research is in biotechnology - not with the release of genetically-engineered organisms but rather with the commercialization of the broader application of molecular biology, e.g., the use of natural microorganisms, biorational pesticides, biologics, etc. I need to tell you this so that you will know my prejudices in the application of biology in solving the research problems of agriculture. However, as Chairman of the National Agriculture Research and Extension Users Advisory Board I represented the eleven (11) disciplines of our 25 members: farmers, environmentalists, marketing, labor, foreign research, farm suppliers, consumers, rural development, human nutrition, animal health and transportation.

Everyone now knows that the 1980s changed agriculture. What is less well known is that the breadth of agricultural research started to expand dramatically during the 1970s. Its breadth now includes the fundamental sciences of biology.

For example, only one-half of Uncle Sam's funding for agriculture research is now funneled through the U.S. Department of Agriculture.[1] And 40% of all the active agricultural scientists and engineers earned Ph.D degrees outside applied agricultural disciplines.[2] These fields include biochemistry, bacteriology, genetics, molecular biology, plant and animal physiology, zoology, botany, economics, ecology, sociology, plant pathology, entomology, and other sciences.

In earlier times, our land-grant colleges of agriculture and its funding agency, the USDA, represented the entire universe of agricultural research in America. Today, however, good public and private research programs reach beyond most of the traditional departments found in our colleges of agriculture.

In my opinion traditional USDA funded agricultural research is caught in the middle of a player change just as the game rules are being changed. The change in the game rules is being brought about by two dislocations. The first results from the earth's ability to feed itself for the first time in recorded history. The second results from the necessary broadening of the scientific base in agricultural research to include the fundamental sciences outside of the land-grant colleges of agriculture.[3]

The first change means that we must now develop new technologies to reduce the costs of inputs to make us more competitive in a world market. These new technologies must be inexpensive to reflect the lower market value of world commodities. We must become more business-like in our approach to research and not just single-mindedly going after higher yields. We need to recognize that most of our older technologies were designed to simply increase productivity and were introduced at a time when farmers could afford them.

---

[1] Anson R. Bertrand, Inventory of Research, Extension, and Higher Education Related to Food and Agriculture, USDA, Science and Education, March 1982

[2] Educating the Next Generation of Agricultural Scientists, National Research Council, Board on Agriculture, 1988

[3] W.E. Marshall, What the Public System Should Be Doing, Ag History 61:296-302 (1988)

With today's commodity prices and the structure of world agriculture, we need to recognize that increases in productivity will not guarantee increases in profitability. Corn farmers in 1985 had to have yield increases of 22 bushels an acre just to pay for the increased costs of inputs versus 10 years earlier.[4] He is caught in a scissors effect of declining commodity values and increasing costs of input. Today's - and tomorrow's - input technology must be cheaper to reflect the lower value of the farmer's crop.

The second change indicates that agriculture is building a new scientific base in addition to the existing chemical and mechanical bases. Biotechnology provides our best hope as the strategy to achieve this new low cost input technology. I don't mean simply genetic engineering but the broadest definition of biotechnology - the technology resulting from the application of all the new knowledge of molecular biology. All those fundamental departments can be expected to play a role. But biotechnology needs to be used wisely; pursued because of its low-cost potential. It will not help agriculture to develop a high-priced biotechnology for low-priced commodities.[5]

The use of biology to help agriculture is in full swing.[6] The federal and state governments and the private sector are supporting it handsomely. But the problem is that most of this support is not going to our colleges of agriculture and is not being administered by the USDA. The reason is that most of our colleges of agriculture don't have the fundamental departments to do practical biotechnology. In my opinion, no more than 15 of our 57 experiment stations have the capability to do significant amounts of research in biotechnology. Furthermore, our experiment stations are not carbon copies to one another. What can be said about one cannot be said about another.

Most of the fundamental departments of science are found in the colleges of arts and sciences within our land-grant universities. At present there is insufficient collaboration between these two colleges. I believe that it is in these fundamental departments and in the private sector that one finds the 9,000 Ph.D's working in agriculture that didn't graduate from colleges of agriculture. And it is also here that one finds one-half of Uncle Sam's investment in agriculture research being wisely spent.

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[4] W.E. Marshall, Applied Agricultural Research, 1:131-136 (1988)

[5] *Appraisal of the Proposed 1988 Budget for Food and Agricultural Sciences*, Report to the President and Congress, National Agricultural Research and Extension Users Advisory Board, (1987) USDA

[6] J.H. Anderson, *Choices*; Second Quarter, p.22-23, (1988) USDA

Generally speaking, there is adequate growth of federal support for agricultural research in the U.S. The issue is that most of our colleges of agricultural research have not been part of the growth because they don't have fundamental science departments in them. And that is where both federal and private money is going these days.

In my opinion, the answer to the funding problem of our colleges of agriculture is not: making agriculture more attractive to students, or centralizing control of their research agenda, or emphasizing the importance of applied faculty research, or switching to non-farming areas, or even more funding.

What not to do? Don't tamper with the competitive grants or the peer-review system. Don't believe that biotechnology is a passing fad. When you hear the phrase "agricultural research" don't just think of our land-grant colleges of agriculture.

I would ask that when you hear the phrase "agriculture research in the public sector" you think not only of the 50% being done in our colleges of agriculture, but also of the other 50% being conducted in fundamental departments being supported by NSF, NIH, DOE, etc. A holistic view is a more accurate view and you are responsible for all federal funding of all ag research, not just that portion funneled through the USDA.

Ask the next administration to account for agricultural research spending across all federal agencies, not just through the USDA. Put a provision in the next Farm Bill that places a higher priority on any federal research proposal that is a collaboration between an applied ag researcher in a college of agriculture and a scientist in a fundamental department.

Causing these two forces to join together will have an enormous, positive effect in the foreseeable future on our productivity and profitability and also on the funding of our colleges of agriculture. The strength of our nation is in both scientific discovery and application. Technology transfer needs to be hastened between basic and applied research.

Also, education in agriculture needs to be toughened - both in entrance requirements as well as curricula. To be competitive in a tougher world market, we can no longer afford agriculture its special status of academic mediocrity.[2]

Likewise, the faculty in extension need to be better trained in the fundamental sciences to act as the third leg of the stool, with researcher and the farmer.

In summary, the goals of agricultural research need to include cheaper biological inputs to support lower commodity prices. The strategy needed to accomplish this requires strong research coordination between the fundamental sciences and the traditional applied ag sciences. The extension programs will provide new practical knowledge for old and new clients.

Again, thank you for the privilege of addressing you.

Senator **Conrad**. Now I want to turn to my colleague, Chairman Brown, for any opening statement that he might wish to make.

STATEMENT OF HON. GEORGE E. BROWN, JR., A REPRESENTATIVE IN CONGRESS FROM THE 36TH DISTRICT, STATE OF CALIFORNIA

Mr. **Brown**. Thank you very much, Senator. I had assumed that in your wisdom you had already included my very eloquent opening statement in the record, and if you have not, I will ask your permission to do so now, and we can proceed with these excellent witnesses.

Senator **Conrad**. Without objection.

[The prepared statement of Mr. Brown of California can be found on page 4.]

Senator **Conrad**. In my opening statement I indicated how pleased I was to be joining you. I attributed all of the wit and wisdom of this committee to you.

Mr. **Brown**. Very flattering, and largely untrue, but nevertheless very flattering.

Senator **Conrad**. I thought it would be found acceptable. What we thought we would do, if it is all right with the panel, is proceed with the statements of everyone, and then have a chance to open it up for questions so that we can involve everyone. We have found that in proceeding that way we perhaps have the most productive discussion.

And our next witness is Dr. Ted Hullar, the Chairman of the Board on Agriculture at the National Research Council, and chancellor of the University of California at Davis. Welcome.

STATEMENT OF THEODORE L. HULLAR, CHANCELLOR, UNIVERSITY OF CALIFORNIA AT DAVIS, DAVIS, CA, AND CHAIRMAN, BOARD ON AGRICULTURE, NATIONAL RESEARCH COUNCIL

Dr. **Hullar**. Thank you very much. I am pleased to be testifying with you today. My name is Theodore Hullar. I am the chancellor of the University of California at Davis. I am a research biochemist by training and my career experience has focused on environmental issues and agricultural research along with medicinal chemistry, doing that in both universities and in government, both at the local county level and also in New York State government, and currently in a liaison capacity with the California State government.

I have served as the Deputy Commissioner for Programs and Research in the Department of Environmental Conservation for the State of New York, and also I have served 3 years as Director of the Agricultural Experiment Station at Cornell University. I now serve on the Board on Agriculture at the National Research Council to which I was appointed to the chairmanship on July 1, 1988.

Let me not read my statement in toto, but rather raise to our attention just some parts of it starting on page 1. In the past, I think it is fair to say the focus of the agricultural research system, combined with the Extension System, has been on improving crop production, and that has paid off very handsomely.

But many persons inside the agricultural system as well as outside are wondering if the current base of knowledge or the past base of knowledge is adequate for the future. Our considered conclusion is no, it is not, and there are a myriad of examples that we can use and which might well be mentioned today.

SCIENTIFIC ADVANCES AND CHANGING PUBLIC PRIORITIES

There are some other factors that are affecting us. First, agricultural research priorities are very clearly shifting from increasing of production to other areas such as, to list just a few, environmental stewardship, food safety, improved nutritional quality, and new uses for agricultural commodities.

Second, and probably even more importantly, is that there is a revolution going on that has exceptional value, and we believe quality, for agriculture. It is in many areas, such as the information sciences, but it is particularly noteworthy in the biological sciences in such areas as recombinant DNA technologies. At least two of our panelists here today are actively involved in them in the research way, and Dr. Marshall is involved with them in an industrial way.

Combined with that, however, we can see a number of more practical and applied challenges, and I have listed these, at least some of these, on the bottom of page 1 of my prepared statement: food safety and nutritional quality; land stewardship and environmental quality; new uses and diversification of agriculture products; the diversification of agriculture for economic development, human resources and education; and of course, the question of efficiency, economic performance, and competitiveness.

PROBLEMS

We can list a number of problems. I have tried to do some of that on page 2 of my prepared statement.

Scientific and technical developments in fertilizers, pesticides, antibiotics and growth-regulating substances have certainly increased agricultural production, but they have also raised problems with such matters as water quality and food safety. We need to establish and develop a knowledge base that can help resolve these problems, preserve the benefits of those technologies and still satisfy regulatory concerns.

Metabolic detoxification of harmful pollutants and new and better uses or products from starch, cellulose, and other renewable resources derived from agriculture could most definitely help recycle elements for a cleaner environment.

The agricultural commodity surplus and the policy programs here and abroad that have helped to maintain them have very clearly distorted very seriously the economic incentives in farming. As a result, top quality young scientists are not attracted into agricultural research and innovation is clearly lagging. If the revolution now under way in biology has the potential to transform civilization in a greater and more rapid way than the industrial revolution did, as some have predicted, we can expect major, rapid changes ahead for agriculture. But where is the engine and what is the engine that will drive this change in building the knowledge base for agriculture?

Part of the engine is the research talent and leadership that already exists within the agricultural research system; and part of the engine will come from other areas of science and technology. New tools and discoveries in a variety of research areas such as protein structure, computer and information science, molecular and cellular genetics and developmental biology, materials science and, indeed, sociology and economics can all be put to work on agricultural problems, put to work in new and even more useful ways. Agriculture most clearly needs to keep pace with this growing science base, and it must tap its strengths. The easiest and most effective way to do this is through a major expansion, not retention, but expansion of our system of competitive grants for agriculture research.

CONTINUITY AND FLEXIBILITY IN FUNDING

On pages 3 and 4 I have set forth what some of this research initiative can be, and I would like to summarize this very briefly.

There are, of course, two important sources for funding for agricultural research: formula funding and competitive grants. It is our belief that the formula funding must be continued. I am fully aware of all the criticisms raised about formula funding, and all the things that have been said, and that we might say here today.

It is my considered belief that formula funding for a myriad of reasons should be continued, possibly at the same rate of growth that it has had in the past, but it should not be diminished.

It certainly is my view, as I have already stated, that the competitive grants program should be dramatically increased. There are a number of benefits that derive from that.

In the middle of page 3, I state, "Today, the public support for agricultural research is not in healthy balance between continuity of funding and competitive grants. In 1988 the competitive grants program in USDA was only $42 million, while the balance of the USDA research budget for ARS and CSRS was $800 million, plus the State contribution of approximately $1 billion. This adds up to a very lopsided ratio of 43 to 1 against competitive grant support. I do not see how agricultural research can catch up or even keep up with the pace of scientific discovery if this lopsided ratio continues. We need a major funding initiative in peer reviewed, competitively awarded grants—grants that select for quality research in promising new areas. I agree with those who call for a major increase of $500 million per year in a competitive grants program. This, I believe, and many others believe, is but a small investment compared with the more than $20 billion spent each year for commodity support programs—a very small investment to ensure the future competitiveness of U.S. farming."

A COMPETITIVE GRANTS INITIATIVE

Let me shift then to page 4 and talk a bit about this grants initiative. Let me turn our attention to two major elements of this. First is in the bulleted section on page 4.

I propose a competitive research grants program at the level of $500 million per year that is organized and peer reviewed to focus on core areas of science and knowledge such as, and I start by listing three broad areas: chemistry, biochemistry, and genetics; organismal biology; environmental biology and ecology. Let me pause there.

If one looks at those three, we realize that we have encompassed biology from the molecular level all the way to the ecosystem level in ways that is actually currently done in a variety of other Federal programs, as Dr. Marshall has said.

But here we are bringing it together in an integrated way. The fourth item is engineering and materials science, and the fifth is economics and sociology. There is deep belief in our community that the fourth and fifth items are also necessary. Those five are the core science areas.

The next part of that paragraph goes on to say, in a matrix-like fashion, research is proposed to address a list of priority areas, or issue areas, such as water quality, new biotechnologies, genetic crop improvement, soil erosion, pest control, toxicology, food preservation, animal health, rural development, or expanded uses for commodities. Research would be evaluated first on the scientific merit and then on the relevance to agriculture.

That bears a striking similarity to what is presently done in the various NIH funding programs. For NIH there is a mission component, and the research is done in relationship to both the frontiers of those research areas, the core science areas, and it is also done in relation to these more practical issues of NIH's category, improved health care. This is improved farming care, or agricultural care, if we can put it that way.

Peer review is clearly the best mechanism available for the selection of high quality research. And, the flexibility provided through competitive grants assures that high quality research will be conducted from a variety of perspectives.

Competitive peer-reviewed programs can be structured in a variety of ways. For example, as scientific and technical approaches are developed in other fields, such as computer and information science, they can be drawn into collaborative efforts with agricultural scientists. This would be possible by making all nonprofit research groups eligible for these grants. Special programs targeted to smaller institutions with limited research staff can help them identify and build upon their special research strengths. Both the National Science Foundation and the NIH have designed competitive programs that focus on helping research programs become more competitive. Grant programs that target cooperation and collaboration among several universities should also be designed to foster more effective research teams and efficient use of facilities.

And we can talk in the discussion about encouraging the use of multidisciplinary teams such as Dr. Marshall mentioned, something that many of us believe would be highly valued. There are many benefits to a strong program in competitive grants.

Research funding helps recruit and retain top-quality young scientists into agricultural research. It is my considered view that many persons, myself included, would have been attracted initially and stayed wholly within agricultural research if there had been even the smallest prospect of sustained funding in the agricultural research areas. That was not the case 20 or 25 years ago. The only route was, in fact, in the NIH and NSF programs.

New areas of productive research would be quickly established. For example, as research tools and strategies become available for tackling basic biological problems, such as drought and cold tolerance, or the control of growth and dormancy in plants, such avenues of research can be quickly funded and explored.

Lastly, I am pleased to note that there is widespread support for the level and direction of this initiative. The Executive Committee of the National Association of State Universities and Land-Grant Colleges, NASULGC, and the Board of Division of Agriculture of NASULGC, and the Council of Administrative Heads of Agriculture have, just in the past 2 weeks, unanimously endorsed this approach for a $500 million a year initiative in competitive grants to expand our thrust and strength in research related to things related to agriculture.

Thank you very much, Mr. Chairman, Mr. Brown. I am pleased to present this to you.

[The prepared statement of Dr. Hullar follows:]

Testimony of

Dr. Theodore L. Hullar
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Before a joint hearing of the
Subcomittee on Agricultural Research, and
General Legislation of the
Senate Committee on Agriculture, Nutrition, and Forestry

and the

Subcommittee on Department Operations, Research,
and Foreign Agriculture of the
House Agriculture Committee

September 29, 1988

My name is Theodore Hullar. I am the chancellor of the University of California at Davis. I am a research biochemist by training and my career experience has focused on environmental issues and agricultural research in universities and government. I have served as the deputy commissioner for programs and research in the Department of Environmental Conservation for the state of New York and also three years as the director of the Agricultural Experiment Station at Cornell University. I also serve on the Board on Agriculture at the National Research Council, where I was appointed to the chairmanship on July 1, 1988.

The economist Alfred Marshall stated that "Knowledge is the most important engine of production." In agriculture, our experience in the United States with public support for research and the history of the land-grant university system strongly support this maxim. In the past, the focus of the agricultural research system on improving crop production paid off handsomely. But what about the status of the knowledge base that must undergird agriculture, for the years ahead? My response to this question is in two parts: first I will indicate the kinds of changes that the public agricultural research system will be asked to respond to, and then I will outline a program crucial to the continued vitality of the agricultural research system.

SCIENTIFIC ADVANCES AND CHANGING PUBLIC PRIORITIES

There are two important changes going on in science and agriculture that we must consider as we plan for the future. First, agricultural research priorities are shifting from increasing production to other areas such as environmental stewardship, food safety, improved nutritional quality, and new uses for agricultural commodities. Second, a revolution is going on across many areas of science and technology and the pace of new discoveries is increasing exponentially. The implications for agriculture are enormous--especially in biology. It is essential that agriculture have the opportunity to participate fully in the biological revolution. To do this, we must create additional funding programs, find the money, and manage new programs effectively.

There are at least five major categories of challenge and opportunity before agriculture today. They might be characterized as:

- Food safety and nutritional quality;
- Land stewardship and environmental quality;
- New uses and diversification of agriculture for economic development;
- Human resources and education; and
- Efficiency, economic performance, and competitiveness.

Scientific and technical developments in fertilizers, pesticides, antibiotics, and growth-regulating substances have increased agricultural production, but have also raised problems with water quality and food safety. We need to develop a knowledge base that can help resolve these problems, preserve the benefits of the technology, and still satisfy regulatory concerns.

We are increasingly faced with the evidence that pollutants from human activity affect the environment, often on a global scale. Some practices in agriculture contribute to these pollution problems, but future discoveries in agriculture also hold the potential to solve many of the ills disrupting our fragile ecosystems. Metabolic detoxification of harmful pollutants and new and better products from starch, cellulose, and other renewable resources of agriculture could help recycle elements for a cleaner environment.

There have been major changes in food consumption patterns in the United States in response to recent evidence connecting human health with nutrition. Demand for and consumption of various commodities will continue to shift until new knowledge is developed to help modify agricultural commodities to better meet human nutritional needs.

Agricultural commodity surplus, and the political programs here and abroad that have helped to maintain them, have distorted economic incentives in farming. As a result, top-quality young scientists are not attracted into agriculture and innovation is lagging. If the revolution under way in biology has the potential to transform civilization in a greater and more rapid way than the industrial revolution did--as some have predicted--we can expect major, rapid changes ahead for agriculture. But where is the engine that will drive this change in building the knowledge base for agriculture?

Part of the engine is the research talent and leadership within the agricultural research system; and part of the engine will come from other areas of science and technology. New tools and discoveries in a variety of research areas such as protein structure, computer and information science, genetics, materials science, or sociology and economics can be put to work on agricultural problems. Agriculture needs to keep pace with this growing science knowledge base and tap its strengths. The easiest and most effective way to do this is through a major expansion of our system of competitive grants.

CONTINUITY AND FLEXIBILITY IN FUNDING

There are two important sources of funding for agricultural research: continuity of support such as formula funding, and competitive grants. A major strength of public support for agricultural research is continuity of funding. Public support through the U.S. Department of Agriculture's Agricultural Research Service (ARS) and the Cooperative State Research Service (CSRS) as well as the support of agricultural experiment stations by the individual states maintains a stable infrastructure of talented people and equipped laboratories. By design, this continuity of funding is not subject to rapid shifts or change. Competitive grants, however, awarded for a two- to five-year period are very flexible and can respond rapidly to initiate and test new areas of agricultural research. For a strong agricultural research system, a healthy balance between these two approaches to public support is needed. The competitive nature of a peer-reviewed grants program should, and does, elicit the best and latest in scientific and technical approaches; while continuity of funding keeps a focus on agricultural problems and priorities. Each has a positive influence on the other: while one responds to the cutting edge of science, the other responds to society's needs and priorities, and adapts research results to agricultural problems. The balance between the two ensures the strongest knowledge base for the future of agriculture.

Today, the public support for agricultural research is not in healthy balance between continuity of funding and competitive grants. In 1988 the competitive grants program in USDA was only $42 million, while the balance of the USDA research budget for ARS and CSRS was $800 million, plus the state contribution of approximately $1 billion. This adds up to a very lopsided ratio of 43 to 1 against competitive grant support. I do not see how agricultural research can catch up or even keep up with the pace of scientific discovery if this lopsided ratio continues. We need a major funding initiative in peer-reviewed, competitively awarded grants--grants that select for quality research in promising new areas. I agree with those who call for a major increase of $500 million per year. This is a small investment compared with the more than $20 billion spent each year for commodity support programs--a very small investment to ensure the future competitiveness of U.S. farming.

A COMPETITIVE GRANTS INITIATIVE

Public funding for agricultural research has stagnated since the 1970s. New funding must be found, and new programs must be initiated to manage the new support effectively. The focus should be a new and expanded program of competitive, peer-reviewed grants that targets core areas of knowledge. The grants must be peer reviewed on both the quality of the science and the relevance of the proposed research to agriculture. While agricultural problems and priorities shift with time, the core areas of knowledge that hold the solutions to these problems are everlasting. Dollar resources dedicated to different priorities can change according to public need, but the merit of proposed research must always be evaluated within core areas of knowledge.

I want to propose a competitive grants program at the level of $500 million per year that is organized and peer reviewed to focus on core areas of science and knowledge such as:

- Chemistry, biochemistry, and genetics;
- Organismal biology;
- Environmental biology and ecology;
- Engineering and materials science; and
- Economics and sociology.

In a matrix-like fashion research proposed to address a list of priority areas such as water quality, new biotechnologies, genetic crop improvement, soil erosion, pest control, toxicology, food preservation, animal health, rural development, or expanded uses for commodities would be evaluated first on scientific merit and then on the relevance to agriculture. These are the priority areas identified by the now well-established planning and prioritizing process of the Joint Council on Food and Agricultural Sciences.

Peer review is the best mechanism available for selection of high-quality research. And, the flexibility provided through competitive grants assures that high-quality research will be conducted from a variety of perspectives. By employing peers in the selection process, research priorities are established by quality rather than only by predetermined category.

Competitive, peer-reviewed programs can be structured in a variety of ways. For example, as scientific and technical approaches are developed in other fields such as computer and information science, chemistry, engineering, or medicine, this talent can be drawn into collaborative efforts with agricultural scientists. This would be possible by making all non-profit research groups eligible for grants. Special programs targeted to smaller institutions with limited research staff can help them identify and build upon their special research strengths. Both the National Science Foundation and the National Institutes of Health have designed competitive programs that focus on helping such research programs become more competitive. Grant programs that target cooperation and collaboration among several universities should also be designed to foster more effective research teams and efficient use of facilities.

There are many benefits to a strong program in competitive grants. Research funding helps recruit top-quality young scientists into agricultural research. New areas of productive research are quickly established. For example, as research tools and strategies come available for tackling basic biological problems, such as drought and cold tolerance, or the control of growth and dormancy in plants, such avenues of research can be quickly funded and explored. And, as we saw in genetic engineering, the basic discoveries were first supported through competitive grants and then quickly adopted by industry for commercial development and the benefit of society.

I am pleased to note that the Executive Committee of the National Association of Land Grant Universities and Colleges (NASULGC), the Board of Division of Agriculture of NASULGC, and the Council of Administrative Heads of Agriculture (CAHA) have recently endorsed this approach for a $500 million a year initiative in competitive grants.

Alfred Marshall, Principles of Economics, 8th ed. (New York: MacMillian) 1920.

Senator CONRAD. Thank you very much. We appreciate your taking the time to be with us. Our plan, Chairman Brown, if it was acceptable to you, is to move through the witnesses and then provide a period for questioning. Is that all right?

Mr. BROWN. Go right ahead.

Senator CONRAD. Dr. Mary-Dell Chilton is the next witness that we have. She is the executive director of agricultural biotechnology at CIBA-GEIGY, and a board member of the National Academy of Sciences Council, from Durham, North Carolina. Welcome.

STATEMENT OF MARY-DELL CHILTON, EXECUTIVE DIRECTOR, AGRICULTURAL BIOTECHNOLOGY, CIBA-GEIGY CORP., AND GOVERNING BOARD MEMBER, NATIONAL ACADEMY OF SCIENCES COUNCIL, DURHAM, NC

BACKGROUND

Dr. CHILTON. Thank you very much. To amplify where I am coming from, I have served for the last 5½ years as the executive director of Agricultural Biotechnology for CIBA-GEIGY Corporation, which is a wholly owned subsidiary of CIBA-GEIGY Ltd., headquartered in Basel, Switzerland. I am currently an adjunct professor of genetics at North Carolina State University, and I serve, as has been mentioned, on the Council of the National Academy of Sciences. I also serve on the Governing Board of the National Research Council, which is the working arm of the Academy. I serve the McKnight Foundation as a member of their peer review panel for plant research projects.

In that context, I have the privilege of being privy to individual and interdisciplinary research grant applications from top universities and from some of the most talented investigators in this country, again in this area of plant science.

I was previously an associate professor of biology at Washington University in St. Louis, and an exclusive consultant to Monsanto, headquartered in St. Louis. My professional training is in biochemistry and genetics. I was fortunate to be one of the architects of the technology that is now in wide use for transferring foreign genes into crop plants. Thus, I come before you as a scientist, academician, funding agent, and industrialist all rolled into one. I shall try to share a perspective from my composite professional experience.

VIEWS ON THREE SPECIFIC TOPICS

I will try to contribute to your deliberations on these matters by offering my views on three specific topics:

The first will deal with university/ARS basic science research. I think that it must serve as the fountainhead of information to keep the United States competitive in the biotechnology revolution that is occurring in the agricultural sector. More Federal funding of research is needed in this field.

The second topic I want to touch upon is we need enhanced collaboration, and we need to avoid duplication of effort between the public and private sectors. ARS and academic research should focus on fundamental research projects and perhaps orphan research projects on which I will elaborate in a moment, projects of lower attractiveness to the seed-selling industry but of high value to the farmer.

The third point I want to touch upon is in order to facilitate technology transfer, the intellectual property rights from federally funded research should be retained by the Federal Government and not relinquished to universities. I'll come back to my reasons.

Let us dwell on the first topic, first. University and ARS research must provide the bulk of basic discoveries about plants. More Federal investment in research in this area is needed. Why do I think this?

Industry collectively cannot scratch the surface of the basic research task ahead of us. It is no secret that companies are in business to make money. Research projects are chosen with the profit motive in mind. There are several kinds of companies doing research in agricultural biotechnology: large companies such as CIBA-GEIGY, Monsanto, and du Pont; seed companies such as Pioneer; and then bioboutiques such as Calgene, Sungene, Phytogen, small venture capital companies that have been spawned by the scientific opportunity and investor optimism.

Now the minimum criteria for research projects in all three types of companies are scientific feasibility, protectability of the product, and attractiveness of the market. That is fairly simple and reasonable. A small venture capital company must focus on short timeframe products for the most part. Large companies with more financial staying power can afford to launch more long-term research projects, but because large business risks are involved, no company would put a major fraction of its R&D effort into fundamental research projects. We do some, but we do not do nearly all that needs to be done.

EXAMPLES OF INDUSTRIAL PROJECTS IN AGRICULTURAL BIOTECHNOLOGY

I cite examples of industrial research projects in agricultural biotechnology which I shall take from the literature to give you an idea of what is being done, and then I will turn to what is not being done.

Examples of what is being done: First, herbicide resistant crop plants are being made. Mainly this research is based on fundamental studies by chemical companies intending to sell herbicide. This research does afford some basic science knowledge, but the scope of it is very narrow. And again, it does not solve this problem. It does not scratch the surface of the task.

A second kind of research is insect resistant crops that contain a single gene that makes either a toxic or a growth inhibitory substance. Specific examples would be BT toxin—that is an insect toxin—or an inhibitor of the protein digesting enzyme of an insect. Those are specific examples of projects that are published. Both genes in these industrial projects came out of academic research programs. One was here in the United States and one in the United Kingdom. So we see industry coming in on the development at the improvement phase, but the fundamental discovery came out of academic research.

Third example: crop plants resistant to specific viral disease are being made, many of them. It is being done by the insertion of a specific gene that is derived from the virus itself. This work again is all based on fundamental studies that have taken place in academic laboratories. I would highlight one, the earliest, which was work of my colleague, Dr. Roger Beachy of Washington University in St. Louis. So that is what industry is doing, at least that they are willing to talk about. Very applied research that was based on fundamental work that happened in academia.

For longer range, high value crop improvement, industry is going to need the results of research projects that are very difficult and not guaranteed to produce a product. Examples of the difficult research areas are:

One, resistance of crop plants—I have a whole laundry list—drought, cold, heat, salt, freezing, predation by a broad range of insects, and probably you could double that list with more ideas. Many genes are involved in these genetic changes. There is no guarantee that you will have anything until you have gone to the trouble of identifying all or at least most of the genes that are involved in these traits.

Second area: creation of crop plants with higher yield. This means either we make more of the crop, or the amount of crop we make we can do at lower cost. The many genes that contribute to yield are unknown. Specific approaches would be to improve, for example, plant architecture or to improve the various biochemical processes of the plant, especially photosynthesis. The feasibility of these concepts is not clear.

A third large area would be development of biological control agents to replace chemical herbicides, fungicides or insecticides. This environmentally attractive objective poses business risks that discourage many companies from doing research in this area. A microbe that kills one specific weed spares most others, so it does not eliminate the need for herbicides. A microbe that kills one kind of insect or one group of fungi merely makes opportunity for others, so you still need insecticides or fungicides in the end. In addition, biocontrol agents do not work as reproducibly as chemicals.

All those difficulties discourage industry from working in this area. It is nevertheless a very desirable area. It might be made to work wonderfully if we do academic research. We need academic research on all three of those broad general topics.

Each of these broad areas needs more fundamental research information before products can even be conceived. There is great opportunity and great need for both academic and ARS programs in these areas. Financial support for academic research in this area of science is woefully inadequate. Symbolic of this is the ease with which we in industry can attract the brightest young scientists: they are concerned about taking an academic position because of very limited Federal funding available for plant research.

Most of the crop plant improvements that I can imagine today are far beyond the scope of present-day knowledge of plant genes. Industrial products are going to be limited by the number and quality of our basic plant science discoveries.

Let us turn to my second area of concern: public sector research should complement rather than duplicate or compete with the efforts of the private sector. In addition to fundamental research projects, orphan research projects not likely to be done in industry at present would be appropriate targets for ARS and/or academic research programs.

I have already argued above that the public sector research must provide most of the fundamental scientific discoveries, since industrial research cannot.

Other distinctions in mission can be envisioned. Industry is unlikely to invest in research areas where the product is not protectable. Hybrid crops such as corn, tomatoes, and a fair number of vegetable crops, have a business protection built into them: the farmer cannot plant back the seeds of his hybrid crop plants and expect the next generation to show the same excellent traits. The traits segregate and the quality falls precipitously.

In contrast, self-pollinating crops such as soybean or vegetatively propagated crops such as potato have no such protection: the farmer can plant back his own material in successive years, after he has bought high value seed only once. Thus, the nonhybrid crops are a target likely to be neglected by industry, yet many of these crops are very large and agronomically important. This is an area which would be especially appropriate for ARS and academic programs.

With limited funds to support research in ARS and academic laboratories, we should seek to focus these efforts in a way that complements industrial work rather than duplicating or competing with it. Academic work can be focused by targeted funding programs. There are more direct means for directing the efforts of ARS scientists. At present, in my opinion, it would be difficult to say what research is outside the scope of ARS: the focus is extremely broad, and it could be narrowed.

My third issue has to do with technology transfer and intellectual property rights. Technology transfer from ARS and academic research to industry is best served if the Federal Government retains intellectual property rights.

Successful research programs will lead to new intellectual property: to patented genes, patented plant seeds, patented microbes, and new plant varieties. If these are developed through the ARS, there are established channels for offering rights to industries wishing to commercialize the discovery. There are appropriate criteria to assure that licensing strategy is pursued in the public interest with a view to product development. Proceeds from such licensing arrangements flow back to the Federal Treasury, an appropriate outcome because taxpayers' money supported the research in the first place.

The picture is different for federally sponsored research programs at universities. In many instances, intellectual property rights are given to the university, which may license them in any way it pleases. The university may find it financially attractive in the short term to give an exclusive license to a single company. This locks all others out of that area of technology. The more fundamental and pioneering the invention, the more impediment such a practice could pose to broad commercial exploitation of the technology.

Let me depart from the prepared text, and remark that the Cohen-Boyer patent on recombinant DNA technology is being handled by the University of California in a very different way. It is being licensed very broadly, but you can imagine if that were not such an enlightened university, and it licensed that technology to one company, it would really distort the whole profile of biotechnology research in the United States.

Back to the text. There are two drawbacks when this happens, and I mean narrow licensing. First of all, it would give foreign competitors an advantage, if the technology is only patented in the United States. Research can be done in other countries that is forbidden to all but one company in the United States. A second drawback is the risk that no product will be made at all. It is still a long research and development road from the fundamental discovery, say a gene or a microbe, to a successful commercial product: the company with the license may not hit upon a successful research approach. From the point of view of getting a product that works, it is strategically advantageous to allow a number of companies to do research based on the patented discovery, and that philosophy is the more important, the more fundamental discovery that we are talking about.

SUMMARY

In summary, I have given you views on three topics. Basic research for agricultural biotechnology is essential, and the bulk of it must come from federally sponsored research programs. More funding is needed to exploit the opportunities offered by this new technology.

Second point: research in academic and ARS laboratories should be different in focus from that in industry; competition should be avoided.

Third point: technology transfer can be more effectively mediated by Federal retention of intellectual property rights.

I hope that these views may be useful to you in your deliberations, and I thank you, Mr. Chairman, for the opportunity of speaking here today.

Senator CONRAD. Thank you, Dr. Chilton. We very much appreciate your taking the time to be with us.

[The prepared statement of Dr. Chilton follows:]

Testimony of

Dr. Mary-Dell Chilton
Executive Director, Agricultural Biotechnology
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919-541-8565

Before a joint session of

The House Agriculture Subcommittee on Department Operations, Research, and Foreign Agriculture

and

The Senate Agriculture Subcommittee on Agriculture Research and General Legislation

September 29, 1988

My name is Mary-Dell Chilton. I have served for the last five and one-half years as Executive Director of Agricultural Biotechnology for CIBA-Geigy Corporation, a wholly owned subsidiary of CIBA-Geigy Ltd., headquartered in Basel, Switzerland. I am currently an adjunct professor of Genetics at North Carolina State University, and I serve on the Council of the National Academy of Sciences. I also serve on the Governing Board of the National Research Council, the working arm of the Academy. I serve the McKnight Foundation as a member of their Review Panel for Plant Research Projects. In that context I am privy to individual and interdisciplinary research grant applications from top universities and the most talented young investigators in this country.

I was previously an Associate Professor of Biology at Washington University in St. Louis, and an exclusive consultant to Monsanto, headquartered in St. Louis. My professional training is in biochemistry and genetics. I was one of the architects of the technology now in wide use for transferring foreign genes into crop plants. Thus I come before you as scientist, academician, funding agent and industrialist rolled into one. I shall try to share a perspective from my composite professional experience.

I will try to contribute to your deliberations on these matters by offering my views on three specific topics:

1. University/ARS basic science research must serve as the fountainhead of information to keep the U. S. competitive in the biotechnology revolution occurring in the agricultural sector. More federal funding of research is needed in this field.

2. To enhance collaboration and avoid duplication of effort between public and private sectors, ARS and academic research should focus on fundamental research projects and "orphan" projects of low attractiveness to the seed-selling industry but high value to the farmer.

3. To facilitate technology transfer, intellectual property rights from federally funded research should be retained by the federal government, not relinquished to universities.

1. University and ARS research must provide the bulk of the basic discoveries about plants. More federal investment in research in this area is needed.

Industry collectively cannot scratch the surface of the basic research task ahead of us. It is no secret that companies are in business to make money. Research projects are chosen with the profit motive in mind. There are several kinds of companies doing research in agricultural biotechnology: large chemical companies such as CIBA-Geigy, Monsanto, and DuPont; seed companies such as Pioneer; and "bioboutiques" such as Calgene, Sungene, and Phytogen, small venture capital companies spawned by scientific opportunity and investor optimism.

The minimal criteria for research projects in all three types of companies are scientific feasibility, protectability of the product, and attractiveness of the market. Small venture capital companies **must** focus on short time frame products for the most part. Large companies with more financial staying power can afford to launch more long term research projects, but because large business risks are involved, no company would put a major fraction of its R&D effort into fundamental research projects.

Examples of industrial projects in agricultural biotechnology are:

Herbicide resistant crop plants, mainly based on fundamental studies by chemical companies intending to sell herbicide. This research affords some basic science knowledge, but the scope is narrow.

Insect resistant crops containing a single gene that makes a toxic or growth inhibitory substance. BT toxin and an inhibitor of the protein digesting enzyme of an insect are specific examples. Both genes came out of academic research programs, one here in the U. S. and one in the United Kingdom.

Crop plants resistant to a specific viral disease because of the insertion of a specific gene derived from the virus itself. This work is all based on fundamental studies in academic laboratories. The earliest was work of my former colleague Dr. Roger Beachy of Washington University in St. Louis.

For longer range high value crop improvement, industry will need the results of research projects that are difficult and not guaranteed to produce a product. Examples of such difficult research areas are:

Resistance of crop plants to drought, cold, heat, salt, freezing, and predation by a broad range of insects. Many genes are involved. There is no guarantee that you will have anything until you identify all (or at least many) of the genes.

Creation of crop plants with higher yield. The many genes that contribute to yield are unknown. Specific approaches would be to improve plant architecture or to improve various biochemical processes, especially photosynthesis. The feasibility of these concepts is not clear.

Development of Biological Control Agents to replace chemical herbicides, fungicides or insecticides. This environmentally attractive objective poses business risks that discourage many companies. A microbe that kills one specific weed spares most others, so it doesn't eliminate the need for herbicides. A microbe that kills one type of insect or group of fungi merely makes opportunity for others, so you still need insecticides or fungicides in the end. In addition, biocontrol agents do not work as reproducibly as chemicals.

Each of these broad areas needs more fundamental research information before products can be conceived. There is great opportunity and great need for both academic and ARS programs in these areas. Financial support for academic research in this area of science is woefully inadequate. Symbolic of this is the ease with which we in industry can attract the brightest young scientists: they are concerned about taking an academic position because of limited federal funding available for plant research.

Most of the crop plant improvements that I can imagine are far beyond the scope of our present-day knowledge of plant genes. Industrial products are going to be limited by the number and quality of our basic science discoveries.

2. Public sector research should complement rather than duplicate the efforts of the private sector. In addition to fundamental research projects, "orphan" research projects not likely to be done in industry at present are appropriate targets for ARS and/or academic research programs.

I have already argued that public sector research must provide most of the fundamental scientific discoveries, since industrial research cannot.

Other distinctions in mission can be envisioned. Industry is unlikely to invest in research areas where the product is not protectable. Hybrid crops such as corn, tomatoes and a fair number of vegetable crops, have business protection built in: the farmer can't plant back the seeds of his hybrid crop plants and expect the next generation to show the same excellent traits. The traits segregate and the quality falls precipitously.

In contrast, self-pollinating crops such as soybean or vegetatively propagated crops such as potato have no such protection: the farmer can plant back his own material in successive years, after he has bought high value seed only once. Thus, non-hybrid crops are a target likely to be neglected by industry, yet many of these crops are very large and agronomically important. This is an area which would be especially appropriate for ARS and academic programs.

With limited funds to support research in ARS and academic laboratories, we should seek to focus these efforts in a way that complements industrial work rather than duplicating or competing with it. Academic work can be focussed by targeted funding programs. More direct means are available for directing the efforts of ARS scientists. At present it would be difficult to say what research is outside the scope of ARS: the focus is extremely broad.

3. Technology transfer from ARS and academic research to industry is best served if the federal government retains intellectual property rights.

Successful research programs will lead to new intellectual property: to patented genes, patented plant seeds, patented microbes, and new plant varieties. If these are developed through the ARS, there are established chanels for offering rights to industries wishing to commercialize the discovery. There are appropriate criteria to assure that licensing strategy is pursued in the public interest, with a view to product development. Proceeds from such licensing arrangements flow back to the federal treasury, an appropriate outcome because taxpayers' money supported the research in the first place.

The picture is different for federally sponsored research programs at universities. In many instances, intellectual property rights are given to the university, which may license them in any manner it pleases. The university may find it financially attractive in the short term to give an exclusive license to a single company. This locks all others out of that area of technology. The more fundamental and pioneering the invention, the more impediment such a practice could pose to broad commercial exploitation of the technology.

There are two drawbacks when this happens. First of all, it gives foreign competitors an advantage, if the technology is only patented in the United States. Research can be done in other countries that is forbidden to all but one U. S. company. A second drawback is the risk that no product will be made at all. It is still a long research and development road from the fundamental discovery (say a gene or a microbe) to a successful commercial product: the company with the license may not hit upon a successful research approach. From the point of view of getting a product that works, it is strategically advantageous to allow a number of companies to do research based on the patented discovery.

Summary:

I have given you views on three topics:

1. Basic research for agricultural biotechnology is essential, and the bulk of it must come from federally sponsored research programs. More funding is needed to exploit the opportunities offered by this new technology.

2. Research in academic and ARS laboratories should be different in focus from that in industry; competition should be avoided.

3. Technology transfer can more effectively be mediated by federal retention of intellectual property rights.

I hope that these views may be useful to your in your deliberations. Thank you for the opportunity of speaking here today.

Senator CONRAD. Next we will hear from Dr. Peter Day, the director of the Center for Agricultural Molecular Biology at Rutgers University. Welcome, Dr. Day.

STATEMENT OF PETER DAY, DIRECTOR, CENTER FOR AGRICULTURAL MOLECULAR BIOLOGY, UNIVERSITY PROFESSOR OF GENETICS, COOK COLLEGE, RUTGERS, THE STATE UNIVERSITY OF NEW JERSEY, BRUNSWICK, NJ, AND FORMER DIRECTOR, PLANT BREEDING INSTITUTE, CAMBRIDGE, ENGLAND

Dr. DAY. Thank you, Chairman. It is a pleasure to be with you this morning. My name is Peter Day, and as you say, I am Director of the Center for Agricultural Molecular Biology at Rutgers, a position I have held since August of last year. Prior to that, I was Director of the Plant Breeding Institute in Cambridge, England, from 1979 until August of 1987, and prior to that again, I was head of the Genetics Department of the Connecticut Agricultural Experiment Station for 15 years from 1964 to 1979. During that period, I served on the NIH Recombinant DNA Advisory Committee, following the meeting in Asilomar in 1976.

CURRENT WORK

I want to talk to you about two things. One is what we are doing in New Jersey and my current assignment as director of this new center.

And second, I was asked to comment on what has happened in Britain to agricultural research, and in particular, my view of the consequences of the privatization of the Plant Breeding Institute in Cambridge.

First of all let me apologize for loading you with a lot of documents, but I felt they were necessary to give you a flavor of New Jersey's approach, and why I am personally really quite excited by the opportunities in New Jersey, and in this area that we're discussing this morning.

The first broad-brush stroke is that New Jersey has a bond issue before the electorate this November seeking $350 million for Jobs, Education and Competitiveness. And one of my attachments, this green sheet,[1] gives you some facts about how the Agricultural Experiment Station in Cook College at Rutgers will benefit from that program.

The other thing that is happening in New Jersey is that the Agricultural Experiment Station is grasping the opportunity to restructure and redevelop itself. And it is doing this in an imaginative way. It established a prestigious Committee for the Advancement of Agricultural Research and Technology (CAART). You can tell how prestigious it is because Dr. Hullar is a member of that committee. I attach its first report, and it identifies a number of interesting initiatives.

The committee has outlined a strategy for raising something like $156 million for facilities over the next 5 years, of which some $77 million is either in hand or anticipated, and when I say anticipated we are pinning our hopes on the bond issue for part of that money. These new facilities include a Plant and Life Science building of which my center will be a part, and an Institute for Marine and Coastal Sciences. Operating costs are planned to increase from the present level of about $17 million to nearly $45 million.

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[1] The New Jersey Agricultural Experiment Station needs YOUR Support! A factsheet on the jobs, education, and competitiveness bond issue.

Part of that plan is in the strategic document which outlines what should be done about Cook College in revising its programs, the research programs within the Agricultural Experiment Station. These are summarized in the document with the rather grandiose title, "Vision 21" which was prepared in 1987, as a result of full consultation with a number of faculty.

FUNDING

It indicates similarly exciting and interesting new developments. I might add that the CAART initiative to assemble this funding is targeted at a number of sources of funding that include, of course, the Federal Government, the State government, the university, the foundations, and industry. All of these play their part.

DEVELOP THE CENTER

Now my assignment is to develop the Center for Agricultural Molecular Biology. The New Jersey Commission on Science and Technology is an agency of the State which directs legislative appropriations toward the setting up and running of advanced technology centers. It has established seven of these.

The one I am involved in is the latest. There is a considerable interest in Federal and industry support of these centers, and this, I suppose, is one of the problems that I have run into in that the amount of competitive grant money that is available currently to support the $4 or $5 million in operating expenses. My center is expected to have 16 research groups, with a total staff of about 150 people. It is expected that 50 percent of that expenditure will come from non-State sources, from industry, Federal Government, foundations, and so on.

The opportunities are rather few and far between, as the other speakers have so eloquently testified to. So I am worried that we need more money for peer reviewed competitive funding. I am confident that when I have assembled the staff, we will be in there pitching for that money effectively.

The development of the center is in three phases. First, to establish some research groups in plant molecular biology using existing and remodeled space at Rutgers. Second reflects an interesting question that I had to resolve on coming to Rutgers: where the center was going to be located? Should it be part of the prestigious faculty of arts and sciences which is on one side of New Brunswick, or should it be where there are clients and customers who can make use of its technology on the agricultural campus?

I chose the agricultural campus, not only because it is being restructured, but because of the need for this kind of technology that will be relevant to the problems facing New Jersey agriculture.

So the second phase is to occupy a building that is under construction at the moment. It will be ready in August. It will help the center to build to half-strength. The third and final phase, for which the bond issue is a crucial part, is to design and plan the final building for the center which is expected to be operational in about 4 years from now.

So I was attracted to Rutgers by the scope and imagination of these plans and believe they constitute a realistic and exciting model for restructuring agricultural research and development in an urban and industrialized State which faces many problems that other States do that are not major agricultural producers.

WHAT WILL WE BE INTERESTED IN?

What are the sort of things that we will be interested in? Well, just to give you an example, long-term strategic research, certainly of the kind that Mary-Dell mentioned that is not competitive with industry. I and a colleague have spent a very interesting past few months visiting with some 9 or 10 corporate research headquarters based in New Jersey with an interest in this kind of research, to discuss what we should be doing.

RESEARCH ON THE PROTEIN SUBUNITS IN THE ENDOSPERM OF WHEAT

We have had all kinds of support for just the sorts of things that Mary-Dell has referred to. As an example, in Cambridge, in Britain, the Plant Breeding Institute (PBI), was doing research on the protein subunits in the endosperm of wheat. That research led to greatly improved methods of selecting for baking quality, by selecting protein subunits that complement each other.

This knowledge has led, in turn, to the successful isolation of some of the genes that code for the subunits. My former colleagues are generating the ability to manipulate wheat by more efficient methods, which is of direct interest to the food industry, even though it is long term in nature.

THE CHANGING ROLE OF STATE BREEDING IN BRITAIN

Now let me change pace and turn instead to a discussion of the changing role of state breeding in Britain. The Plant Breeding Institute, when I arrived in 1979, was regarded as the flagship of the Agricultural Research Council. It was an organization that had outstanding fundamental research in molecular biology, cytogenetics, and genetics.

But the extraordinarily interesting thing about it was that this was coupled with very effective plant breeding in producing agronomic crops for farmers. So the PBI was a household word on the farm.

To give you an instance, Winter wheat in Britain. You could drive anywhere in the country in the last few years, and make the confident statement that over 80 percent of the wheat you saw around you originated in Cambridge at the PBI.

It was a very profitable operation. The varieties were marketed to the seed industry through a QUANGO, a quasi-non-government organization, a piece of British jargon, called the National Seed Development Organization. Its income, principally from royalties, was about three times the total running costs for the Plant Breeding Institute.

Although that organization was set up to market the products of state breeding in Britain, in fact, about 70 percent of its revenue was attributable to the work of the PBI. Now you have heard about the swingeing cuts to agricultural research in Britain. In 1984 and 1985, it had to adjust to major cuts in funding, losing some 600 staff out of a total workforce of about just over 5,000, who were forced to leave the Research Service by compulsory redundancies. At PBI we had to start closing a number of breeding programs.

We thought we would be in good shape to meet 1986, but then the government imposed further massive cuts on the Ministry of Agriculture and Agricultural and Food Research Council (AFRC), that together totaled something like $30 million.

AFRC established, in their wisdom, a Research Priorities Board which was to provide advice on what research to keep and what to jettison. This board recommended seeking industry support for certain R&D activities, including plant breeding.

Of course, the first thing the Ministry analyzed was the prospect of selling the National Seed Development Organization because it was making so much money. They very quickly realized that to do this without also assuring it of a supply of new finished varieties, it would simply be selling a wasting asset.

So they came to the decision that the appropriate thing to do was to sell the NSDO and the PBI together. They appointed a merchant bank to assist them in drawing up specifications for the sale.

That was a very interesting period in my career, working with a merchant banker, telling them what we did, helping them to describe it in a glossy brochure, which I had to do as a good public servant, although I was violently opposed to it, and I and the PBI governing body tried every strategy we knew to prevent it.

One of our major strategies was do not sell it. Let it support itself, and let the Treasury pocket the profit. That was not acceptable, and eventually the operation was sold. I think it was a political decision based on the government's view that anything that was state supported that was making a profit would make a thundering sight better profit if it were privatized.

I am a believer in privatization. But I think the thing that went wrong, and one of the most important consequences of the decision to privatize the PBI, was that they did not privatize all of it.

The Research Council kept the basic work on the premise that if that were sold, it was going to have to reconstitute it any way because it was part of their mandate from the government. So that was not sold. The plant breeding activity was sold together with the site, and Unilever won the competitive bidding and paid 68 million pounds for it.

The most important asset they purchased was this absolutely first-class wheat breeding program. What was disrupted was the technology transfer that we had honed over 75 years. We celebrated our 75th anniversary in 1987, and Princess Anne and her husband were there. Everyone thought it was going to be a wake. It was not. It was a very interesting occasion.

What was important was the pulling influence of breeders down one end of the corridor and first class molecular biologists at the other who were working together in a very interesting way.

Theirs is a difficult dialog because they speak different languages. They work in entirely different time frames. The breeders are out in the field with muddy boots on, and the molecular biologists are in the labs with white coats doing experiments with organisms with generation times of 20 minutes or half an hour.

The breeders work with generation times of 3 to 6 months. So you can understand. But it was working, and it is now disrupted, and it will take many years to restore.

WHAT IS THE LESSON IN THIS FOR THE UNITED STATES?

The public sector must shoulder the burden of long-term, high-risk research to solve important fundamental problems. Mary-Dell listed a number of them. Drought, stress, temperature extremes, salinity, air pollution and so on. To do this it must have access to modern facilities and technology. Neglect will result in short-term, opportunistic research. Well organized centers must have stable funding from a variety of sources. What happened to the PBI was totally inconceivable 3 years ago. In fact, other directors envied me. They saw all the cuts. They said you are not going to be touched. You are so cost effective.

In a sense, we were too good. So it is a warning that we must safeguard what we have and continue to build for the future. Thank you, Mr. Chairman.

Senator CONRAD. Thank you very much.

[The prepared statement and accompanying information of Dr. Day follow:]

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Testimony to the Joint House-Senate Agriculture Committee

by

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Cook College
Rutgers, The State University of New Jersey
New Brunswick, NJ 08903

I. Current Work

My assignment is to develop a Center for Agricultural Molecular Biology as a joint venture between Rutgers University and the New Jersey Commission on Science and Technology. It is planned to consist of 16 research groups covering plant, animal, and environmental science aspects of molecular biology. With start-up funds from the Federal Government, the State of New Jersey and Rutgers University, the Center is expected to draw about 50% of its operating budget from government agencies, foundations and industry, principally through competitive grants. Annual costs will be between $4 - $5 million.

A New Jersey bond issue before the electorate on November 8 seeks $350 million for Jobs, Education and Competitiveness. Seventeen million dollars of this is earmarked for building the Center and $3 million for a Biological Impact Assessment Center at the Rutgers Research and Development Center in southern New Jersey. Federal government assistance in establishing the Center is crucial. The Center will compete for federal grants for Science and Technology Centers and/or Plant Science Centers. Unfortunately, these programs are now very much underfunded. New Jersey's commitment to this expenditure will be greatly influenced by such support.

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*Dr. Day was Head of the Genetics Department of the Connecticut Agricultural Experiment Station from 1964-1979 and Director of the Plant Breeding Institute, Cambridge, England from 1979 until August 1987 when he moved to Rutgers.

Development and recruiting are in three phases: first, to establish research groups in plant molecular biology using remodeled and existing space at Rutgers; secondly, to occupy temporary quarters under construction which will accommodate six more groups at Cook College; and thirdly, to design and occupy a building that will house the Center, together with the Departments of Horticulture, Plant Pathology, Entomology, and Plant Science.

The Center will work closely with the Waksman Institute and the newly developing Center for Advanced Biotechnology and Medicine. It will provide research and training in agricultural biotechnology for Rutgers University and for industries in New Jersey and other states.

The research program will be strategic in nature, focusing on long-term needs related to practical objectives. As an example, research on the protein sub-units in the endosperm of wheat at the Plant Breeding Institute in the U.K. led to improved and more efficient methods of selecting for baking quality by selecting sub-units that complement each other. This knowledge led in turn to the successful isolation of some of the genes that code for these sub-units. The ability to manipulate wheat with more efficient methods is of direct interest to the food industry.

The Center For Agricultural Molecular Biology is only part of an overall plan for renewing New Jersey's commitment to agricultural research. A prestigious committee for the Advancement of Agricultural Research and Technology (CAART), of which Dr. Hullar is a member, has developed a broad financial strategy for the station that seeks funding from the State, the Federal government, the University, the foundations, and industry. This is projected to raise $156 million for facilities over the next 5 years of which some $77.1 million is either in hand or anticipated. These include a Plant and Life Science Building and an Institute for Marine and Coastal Sciences. Operating costs are planned to increase from the present level of $17.7 million to about $44.6 million each year. (A copy of the first CAART Report is attached).

An ambitious strategic plan for Cook College and the New Jersey Agricultural Experiment Station is outlined in a second document "Vision 21" (attached).

I was attracted to Rutgers by the scope and imagination of these plans and believe they constitute a realistic, exciting model for restructuring agricultural research and development in an urban and industrialized state. Many of New Jersey's problems (pollution, water quality, maintaining farming communities, servicing industries, etc.) are faced by agriculture in many other parts of the U.S.

The Changing Role of State Breeding in Britain

I was asked to make some comments about my experiences during the organizational upheavals that have affected agricultural research in Britain during the last several years. I discussed this briefly in a lecture in Brighton, U.K., in 1987 and set out below an edited and updated version of my comments.

The introduction of plant variety rights in Britain in 1961 raised the question of how state-supported and private breeders could coexist. Was it fair to use taxes to support a state organization that competed for the same market? The private sector breeders argued for a system used in Holland whereby state breeders produce only advanced lines for distribution to the industry and may not release finished varieties. The state breeders argued that release to farmers provided the ultimate test-bed of their research and development ideas. The direct contacts with farmers, the seed trade, and end users such as millers, maltsters and processors gave direction and impetus to their work that they believed was missing in the Dutch scheme. The kudos and recognition attached to success was also a very important stimulant to further effort.

The system led to the establishment of a very effective Plant Breeding Institute which not only carried out first class basic science, but produced a series of extremely successful crop varieties. PBI was an example of effective, on-going technology transfer that was widely admired throughout the agricultural world. It was the flagship of the Agricultural Research Council (ARC).

In 1984 and 1985 the ARC--now renamed AFRC (Agricultural & Food Research Council)--had to adjust to major cuts in funding. Staffing reductions resulted in some 600 staff being forced to leave the research service. At PBI a number of programs had already been stopped including breeding forage maize, red clover, lucerne and durum wheat and exploration for new agronomic crops. These moves culminated in the closure of the Sugar Beet Department in March 1986. Other work on aphid resistance in cereals and research on the development of the cereal meristematic apex was also stopped, and engineering and electronic workshops were closed. The triticale breeding program was also scheduled for closure but was acquired by a private sponsor (Semundo, Ltd.).

As a result of these measures, PBI faced 1986 confident that its major programs could continue unimpaired. However, AFRC then had to adjust to a further massive cut in Ministry of Agriculture Food and Fisheries (MAFF) support for R&D totaling L20m (ca. $30 million) which was to be born by the Agricultural Development and Advisory Service (ADAS) and AFRC during 1985-86 and 1986-87. A Research Priorities Board was established to provide advice on what to keep and what to jettison. This board recommended seeking industry support for certain R&D activities including plant breeding.

In the meantime, MAFF had begun to analyze the prospect for finding a purchaser for the National Seed Development Organization (NSDO) which they had set up soon after plant variety rights were established in the sixties for the purpose of marketing the products of state breeding. They soon realized that unless NSDO was assured of a continuing flow of improved varieties it could only become a wasting asset of little value as its portfolio of varieties became out of date. NSDO's earnings, principally in the form of royalties levied on the sale of seed to farmers, were substantial. Over 70% of them derived from PBI varieties. A merchant bank, Lazard Brothers, was appointed to establish the feasibility of selling the principle source of NSDO's new varieties, the PBI, together with NSDO as a going concern.

It is important to note that during the lean years of reductions and cuts, the breeders had seen the basic science programs expand through the influx of external funding to support work in molecular genetics, biotechnology and cytogenetics. Although some investment was made in plant breeding by redistributing scarce resources, the breeders saw privatization as providing the most likely opportunity for significant additions that would help them to retain their comparative advantage. Even so they were worried by the prospect of losing direct access to the research and science support "down the corridor."

The results of research in basic science do not apply themselves automatically to solving other people's practical problems. The benefits to crop improvement from biotechnology come most rapidly by building bridges between breeders and molecular biologists. Direct exchange between these two kinds of scientists is possible but difficult. They use different technical vocabularies, work to entirely different time scales, and don't read the same journals or attend the same meetings. This kind of technology transfer calls for scientists who can work with both groups.

The sale of PBI and NSDO for L68 million to the highest bidder, Unilever, was a political decision taken because of the government's conviction that a state organization that was profitable would be still more so under private ownership. The PBI Governing Body and I argued with the AFRC and the Ministry for an alternative plan, namely to allow the PBI and NSDO to be self-financing, returning the surplus to the Treasury. This was not acceptable.

One of the most important consequences of the decision to privatize PBI/NSDO was the disruption of the partnership between breeders, molecular biologists and cytogeneticists. This destroyed the important pulling force to generate relevant basic science to satisfy the breeders' wants that everyday access created. It will take many years to restore.

What is the lesson for the U.S.? The public sector must shoulder the burden of long-term, high-risk research to solve the important fundamental problems of drought stress, temperature extremes, salinity, air pollution, and so on. To do this, public sector agricultural research must have access to modern facilities and technology. Neglect will result in short-term, opportunistic research. Well organized centers must have stable funding from a variety of sources. What happened to PBI was inconceivable three years ago. It is a warning that we must safeguard what we have and continue to build for the future.

Attached material follows:

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

THE NEW JERSEY AGRICULTURAL EXPERIMENT STATION

NEEDS YOUR SUPPORT!

A FACT SHEET

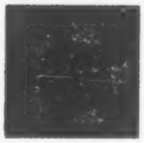
ON THE JOBS, EDUCATION AND COMPETITIVENESS BOND ISSUE

WHY IS THE BOND ISSUE IMPORTANT TO NEW JERSEY ?	**The $350 million Jobs, Education and Competitiveness bond issue** on the ballot November 8, 1988 will provide $33 million to build and upgrade facilities in New Brunswick and at research centers throughout the state to help the New Jersey Agricultural Experiment Station (NJAES) and Cook College improve research, teaching and extension outreach to clientele.
HOW DOES NJAES HELP NEW JERSEY ?	**NJAES is the research and extension arm of the state concerned with renewable natural resources. Additionally, the Experiment Station contributes to the quality of life through environmental research, assists the state's marine and coastal fishing industry, and provides family life, nutrition and 4-H programs to inner city, suburban and rural New Jerseyans.**
HOW WILL THESE FUNDS BE USED THROUGHOUT THE STATE ?	$6 million will be used at statewide field stations: South Jersey Research and Development Center, Bridgeton, Cumberland County: * single cluster greenhouse addition with robotics laboratory; * Biological Impact Assessment Center with laboratories, a greenhouse and field plots; * postharvest research labs and greenhouse. Cream Ridge Fruit Research and Development Center,Cream Ridge, Monmouth County: * expand laboratory, office, and equipment storage buildings for postharvest research. Rutgers Marine Field Station, Tuckerton, Ocean County: * renovation of finfish research; * building and dredging of channel.

	Rutgers Shellfish Research Laboratory, Port Norris, Cumberland County, and Cape Shore Lab, Cape May County: * building of shellfish hatchery and aquaculture center.
HOW WILL THESE FUNDS BE USED IN NEW BRUNSWICK ?	To replace antiquated and unsafe facilities, $27 million will be used to match federal funds for the plant science complex, including: * completion of state-of-the-art greenhouses on College Farm Road; * a 280,000 square foot complex on Biel Road between Lipman Hall and the Food Science Building with classrooms, teaching laboratories, an auditorium, lecture halls, a research library, research laboratories, growth chambers and a greenhouse to support teaching, research and extension in the departments of Plant Pathology, Horticulture and Crops, Entomology, Plant Bioscience and the Center for Agricultural Molecular Biology.
WHO HAS BACKED THE BOND ISSUE ?	The Department of Higher Education, the New Jersey Commission on Science and Technology, Rutgers University, Governor Thomas H. Kean, The Committee for the Advancement of Agricultural Research and Technology (CAART), and the legislature support the bond issue.
WHAT DID CAART SAY ?	CAART, chaired by Nicholas Marotta of National Starch and Chemical Corp., and Malcolm S. Forbes, Jr. of Forbes, Inc., called NJAES the sleeping giant of New Jersey's $15 billion food and fiber economy. CAART recommended major levels of new funding and called the bond issue "an essential component of this funding."
WHAT DID CAART RECOMMEND ?	"We urge your support for this and other measures that will carry the station forward and enable it to do the work it must do for all of us in years to come."
HOW CAN I HELP ?	Register to vote in the November 8, 1988 general election. Encourage your family, friends, co-workers, community, and association to register, too.

8/12/88

Meeting
New Jersey's Economic,
Environmental, and
Agricultural Challenges



A Financial Strategy
for the
New Jersey Agricultural
Experiment Station

Report of the Committee
for the Advancement of
Agricultural Research and
Technology

BEST AVAILABLE COPY

"At a time when New Jersey colleges and universities are attracting world-class professors and creating top-notch programs, our provosts and presidents are presiding over crumbling classrooms and obsolete laboratories. This threatens every other advance we have made. Buildings built yesterday are simply not good enough for tomorrow."

GOVERNOR THOMAS H. KEAN
1988 Annual Message to the
New Jersey State Legislature

ON THE COVER
From a commanding past, the New Jersey Agricultural Experiment Station continues its mission in the areas of food technology, production agriculture, marine and coastal sciences, and environmental research.

A Letter to the People of New Jersey

Nicholas G. Marotta

Malcolm S. Forbes, Jr.

SERVICE FOR THE PAST SEVERAL MONTHS ON the Committee for the Advancement of Agricultural Research and Technology (CAART) has led the members of this committee to the overall conclusion that the New Jersey Agricultural Experiment Station is the quiet giant of New Jersey's $15 billion food and fiber economy. Equally clear is the role the station plays in the enhancement of the quality of life for all New Jersey through environmental research and the maintenance of a safe, secure, and affordable food supply. CAART has made thirteen specific recommendations that will assure the station's ability to play a leading role in these and other areas in the coming century.

The work of our committee and its recommendations are tied closely to a remarkable document titled "Vision 21: A Strategic Plan for Cook College and the New Jersey Agricultural Experiment Station." Designed by Dr. Stephen J. Kleinschuster, dean of Cook College and executive director of the station, and his senior staff, "Vision 21" is a blueprint for excellence for the college and station, that clarifies the station's role within Rutgers, The State University of New Jersey, and its statewide responsibilities.

On March 10, 1988, the station marked the 108th anniversary of its establishment as the nation's third state agricultural experiment station. The station's first director was Dr. George H. Cook, whose name is today carried by Cook College. In George Cook's work we find the bedrock foundation of a philosophy of service carried on by the experiment station for the good of all of New Jersey's citizenry.

This station, which has served New Jersey long and well, from the Nobel Prize-winning discovery of streptomycin to today's leading-edge research in genetic engineering, now needs our help. Facilities at the station are outdated. Only two major new research buildings have come into use by station scientists since 1949. Equipment in current use is more suited to an honored place in the state's agricultural museum, and major support is needed to help the men and women of the station toward scientific discovery vital to our common interests.

Our report concludes that major levels of new funding through productive partnerships with the state of New Jersey, the federal government, New Jersey business and industry, foundations, and other sources are desperately needed. An essential component of this funding would be provided by passage of the $350 million "Jobs, Education, and Competitiveness Bond Issue" recommended by Governor Thomas H. Kean in his annual address to the state legislature. We are anticipating that the New Jersey Agricultural Experiment Station would receive $37 million under this proposal. We urge your support for this and other measures that will carry the station forward and enable it to do the work it must do for all of us in years to come.

Nicholas G. Marotta
Malcolm S. Forbes, Jr.
Cochairmen, Committee for the Advancement of
Agricultural Research and Technology

April 1988

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WHARTON STATE FOREST, BURLINGTON COUNTY

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EXECUTIVE SUMMARY

Meeting New Jersey's Challenge of Change

Background to the Study

In 1986, a Rutgers University committee, chaired by Michael Bongiovanni, now chairman of Rutgers' Board of Governors, recommended to that board that the goal for Cook College and the New Jersey Agricultural Experiment Station should be no less than the goal for the university as a whole: to rank among the nation's best colleges of food, agriculture, and natural resources. This goal is consistent with Governor Thomas H. Kean's challenge to Rutgers to become a truly first-class university.

The Bongiovanni committee then called for the creation of a citizens' committee which would bring together the agricultural, business, civic, environmental, and consumer groups that benefit from the works of the New Jersey Agricultural Experiment Station, to assess the needs of the station, and support its budget requests with the chancellor of higher education, at the governor's office, and with the leadership of the legislature.

Rutgers' Board of Governors and President Edward J. Bloustein invited forty-two distinguished leaders from these various constituencies to form this group, the Committee for the Advancement of Agricultural Research and Technology (CAART). The committee was assisted in its work by a liaison group representing the students, faculty, and alumni of Cook College, and by members of the board of managers of the station.

The Committee's Task

In his charge to CAART, Dr. Bloustein asked the committee to "help design the strategy that will win the support the New Jersey Agricultural Experiment Station needs to become the best in the nation. The challenges the station faces include: the preservation of production agriculture; the development of biotechnology; the protection of our coastline and our air and water; the strengthening of our burgeoning food processing and packaging industries; and the elimination of toxic and hazardous wastes—all issues that require research, education, and extension at a truly world-class level. We can't afford second best."

The committee conducted an extensive review of the New Jersey Agricultural Experiment Station and its role in Cook College, the university, and the state as a whole. The committee studied the station's funding needs and compared missions and levels of activity and support for state agricultural experiment stations in other states.

Identifying New Jersey's Needs

The committee framed three fundamental questions: Does New Jersey need a first-class agricultural experiment station, one that ranks among the very best in the nation? Is the New Jersey Agricultural Experiment Station prepared to assume that responsibility? Can the public and private sources available provide the necessary resources? The work of the committee showed that the answer was "yes" to all three questions.

New Jersey is a state that is creating a future of excellence and distinction for its people and their institutions. Critical to the state's vision for the future are the development of its multicommodity agricultural, food, and marine industries; the management of its natural resources; and the enhancement of its environmental quality.

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The New Jersey Agricultural Experiment Station provides such an array of essential services that it is clear that if an institution such as the station did not exist, the best interests of the state of New Jersey would require that one be created.

The station's contributions over the years have included the discovery of the antibiotic that cured tuberculosis, pioneering work in mosquito control and other efforts to improve human health, and the development of such successful plant varieties as the world-famous Rutgers tomato. Today the station is important to our state's $15 billion food, agricultural, and marine industries and other elements of our economy, ranging from pharmaceuticals to tourism. The station also makes key research contributions to the quality—as well as the quantity—of life for us all.

For example, the station works to combat pollution of our air, water, and soil, reduce erosion along our shoreline, and improve the nutritional value of foods while increasing the availability of natural additives in processed foods. The station also works to enhance agricultural production through such diverse strategies as increased use of greenhouses and the latest techniques in genetic engineering.

The committee strongly endorses President Bloustein's view that New Jersey "cannot afford second best" in these critical areas. In light of the station's long and distinguished record of service and contributions to New Jersey, and the tours, discussions, and reviews we have conducted, the committee finds that the New Jersey Agricultural Experiment Station, with the improvements proposed by this committee, will indeed be prepared to assume the responsibility of becoming one of the nation's best.

Steps Toward the Future

For that goal to be accomplished and to foster the dual development of the station and New Jersey's food, agricultural, marine, and natural resource base, a major investment is needed for capital improvements and operating resources for the station and Cook College over the next five years. Vision 21, the new master plan for Cook College and the station, calls for facilities support that this committee has determined will cost $156.1 million in new construction, renovation, and equipment. Of that amount, $77.1 million is either already in hand or anticipated from Rutgers, the proposed state bond issue, and other sources, leaving a goal of $79 million in new funding needed to meet the capital needs of the station over the five-year period. The committee also found that the station's operating budget will have to increase over that same five-year period from $17.7 million annually to a level of $44.6 million per year. These capital and operating investments will also have a significant long-term impact on the station's ability to win competitive grant support.

Financial Strategy

Although the committee feels that the state must be the leading participant in this multifaceted financial plan, no single source can bear the full cost; it must be shared and leveraged. The only way to meet that need is through a productive partnership of funding from a variety of sources.

The committee is encouraged by the support for the experiment station expressed in the governor's recent State of the State Address, the inclusion of $37 million for experiment station projects in the proposed Jobs, Education, and Competitiveness Bond Issue recommended by the New Jersey Department of Higher Education and the New Jersey Commission on Science and Technology, the award of a $50,000 feasibility grant from the U.S. Department of Agriculture, and indications of interest on the part of other agencies in supporting a marine sciences institute.

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The Committee's Recommendations

The committee has developed thirteen recommendations to assure the station's ability to meet the challenges of change.

The State

For the state of New Jersey, the committee urges passage of the $350 million Jobs, Education, and Competitiveness Bond Issue to provide the station with $37 million for unmet construction costs. The state is also called on to increase the station's annual operating budget to $44.6 million in the course of the next five years and to provide $28.3 million in appropriations for construction and equipment needs at the station during the same time period. Also, the New Jersey Commission on Science and Technology is urged to provide an additional $1 million in equipment support.

The Federal Government

For the federal government, the committee recommends approval of $37.2 million in capital support for the plant sciences building and the Center for Agricultural Molecular Biology. The federal government is also encouraged to fund additional competitive grant programs for experiment stations.

Government agencies concerned with the protection of the marine environment are called on to provide $9 million in support of the proposed Institute for Marine and Coastal Sciences.

The University

Rutgers University is urged to continue support for the station under the Fund for Distinction and incentives to faculty members seeking federal grant and contract support for station research projects. The committee also recommends that Rutgers continues to enhance Cook College's instructional programs and strengthen their relationship with the station.

The Private Sector

For the private sector, the committee calls upon industry to recognize the importance of the station and support it through capital and equipment gifts and research grants. Commodity groups and others aided by the station are encouraged to support it as well, and greater participation by foundations and individuals is also urged.

Finally, the committee recommends that Rutgers, Cook College, and the station work to increase public awareness of the station and its services and potential contributions to the state.

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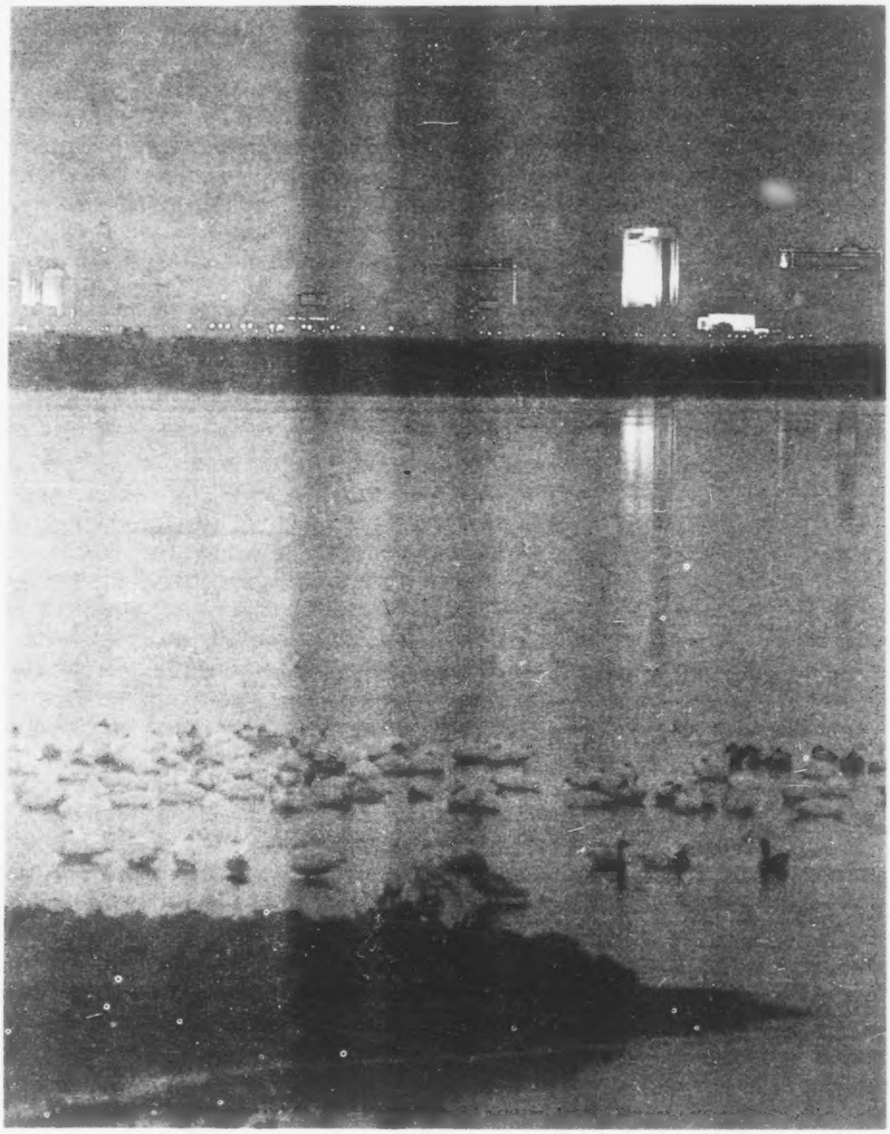

ATLANTIC CITY SHORELINE ATLANTIC COUNTY

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A STATE OF EXCELLENCE

New Jersey is truly a state on the move, sparked by dynamic state leadership, propelled by a well-educated and highly productive workforce, and fueled by the desire to raise the quality of life in New Jersey to the highest possible level for all its residents.

We have been fortunate to enjoy a thriving economy in recent years, which has rewarded us with a standard of living that is among the highest in the land. Thanks to its location and its successes in economics and commerce, New Jersey has become a national leader in business and industry, with a quarter of the nation's population within a day's drive of the state and easy access to major ports serving the rest of the world. At the same time, we have maintained our status as one of the country's most popular tourist destinations.

New Jersey is a state of many firsts and of great momentum and growth. However, our state faces a core of serious problems concerning our environment and natural resources, our food supply, human health, and other areas, the solutions for which pose challenges that we must meet if we are to preserve and enhance our quality of life and economic vigor as we move into the next century.

THE CHALLENGE

Demands on New Jersey's natural resource base will accelerate as suburban development reduces the amount of farmland while increasing the number of mouths that need to be fed. The food industry in New Jersey will face the need to, in effect, make more from less, and do so in the context of heightened concerns about human health and nutrition. Now second only to petrochemicals in the state's economy, food and related industries in New Jersey will be propelled to new prominence in the 1990s and beyond.

Future economic growth is likely to be limited by concerns about environmental impact, with New Jersey again at the forefront of various concurrent ecological crises. The cost of agricultural production will also continue to rise. As this happens, the viability of New Jersey agriculture will depend significantly on economic returns per acre being high enough to keep the land in farming, rather than other purposes.

There is a major need for the development of processes and policies to address New Jersey's deteriorating environmental quality and diminishing natural resource base. State and local agencies require specialized assistance in working with industries in accommodating their operating requirements to environmental and natural resource concerns. All of us want to live, work, and raise our families in a state that has clean air, pure water, efficient waste disposal, and freedom from the dangers of toxic and otherwise hazardous materials.

It is clear, therefore, that our common future requires a base of knowledge and skills leading to new technologies and policies, as well as a method for timely application of knowledge to problems. Fortunately, New Jersey is remarkably well positioned to take advantage of the challenge of change in these fields because we already enjoy formidable strengths.

The New Jersey Agricultural Experiment Station

MEETING THE CHALLENGE

One of the most important of these existing strengths is the New Jersey Agricultural Experiment Station at Rutgers, The State University of New Jersey. The station has a 108-year history of leadership in responding to challenges of the type the state faces in the future. An integral part of New Jersey's nationally acclaimed series of initiatives in science and technology, the station is the research arm of the state concerned with renewable natural resources. As such, it is an important component of the new, productive partnerships among government, research universities, and private industry that form the structure supporting the development of New Jersey's long-range answers to the needs of the future.

The New Jersey Agricultural Experiment Station is home to the nation's oldest university-based department of environmental science, established in 1920. Today, the department conducts a wide variety of research on the impacts of pollution, such as this analysis of groundwater samples.

The station plays a major role in the activities of Cook College, the State University of New Jersey's professional school of agricultural, environmental, and life sciences. The station is funded separately from the general university in the New Jersey budget and receives financial support from the federal government for its mission.

TECHNOLOGY TRANSFER

Cook College brings the land-grant concept—the integration of basic and applied research, teaching, cooperative extension, and continuing professional education—to a broad range of interdisciplinary programs for the benefit of all New Jersey residents. The station fulfills this philosophy through research projects and the work of Rutgers Cooperative Extension, an agency of the station with offices in every New Jersey county, which carries research results from the laboratory to the people of the state.

The college and station are part of the national federal-state cooperative research and extension system established by acts of the federal government in the nineteenth and early twentieth centuries. Research faculty hold joint appointments at both the station and college, where part of their time is devoted to graduate and undergraduate teaching, as well as to research. Extension personnel work in such diverse areas as agriculture and resource management, home economics, 4-H youth development, urban gardening, and marine resources. Support for the extension arm comes also from the county governments of the state. Many research and extension faculty also teach short courses conducted by the college's Office of Continuing Professional Education.

A HISTORY OF ACHIEVEMENT

Established in 1880, the station's accomplishments over the years are important and diverse. They include the discovery of the antibiotic streptomycin which cured tuberculosis, and the development of the world-famous Rutgers tomato and successful peach varieties, artificial insemination techniques for dairy cattle, and control measures for mosquitoes.

Station researchers developed two vaccines in the 1930s and 1940s that helped to save the poultry industry. They have also hybridized Kentucky bluegrass for lawns and other turf uses and pioneered work in interpreting satellite data to help fishermen harvest more productively.

CONTINUING THE TRADITION

Today the station is intricately linked with many of the state's leading industries and makes a substantial contribution to the economy of the state. Its research and extension programs support New Jersey's $15 billion agricultural, food, and marine industries and makes significant contributions to biological products and pharmaceuticals. As an industry, food and agricultural production accounts for the jobs of 67,355 workers, and provides $917 million to New Jersey workers in annual payrolls.

Providing immediate service to New Jersey's agricultural industries was already an established practice of the New Jersey Agricultural Experiment Station by 1915, when this photo of a field botanical laboratory was taken.

The station provides research support for the preservation and enhancement of our environment and natural resources, including our 127 miles of coastline, through such techniques as the development of a statewide watershed management plan and efforts to reduce soil erosion.

Current activities of the station to increase agricultural production include improving disease resistance and yields of plants and animals through genetic engineering and other techniques. Researchers are also working to lessen reliance on pesticides and reduce energy consumption in greenhouses.

MEETING VARIED NEEDS

Station scientists are conducting advanced research to modify microorganisms for the destruction of toxic and hazardous wastes and are involved in numerous efforts to combat pollution of our air and water. They are also working to develop alternative energy sources derived from agricultural wastes.

New Jersey's most precious resource, its children, share many learning experiences through the 4-H youth development program, conducted throughout the state by Rutgers Cooperative Extension.

In other areas, the station addresses such human health concerns as the control of diseases and improvements in the nutritional value of foods. The station has mounted major new initiatives in international food and agricultural programs. Through Rutgers Cooperative Extension, it administers the state's 4-H youth development program, which reaches inner-city, suburban, and rural children, as well as their parents.

There are many other illustrations of the diversity of the station and the variety of its contributions. While it is difficult to calculate the precise dollar value of the station's overall significance to New Jersey's economy, the charts on the following pages show some examples of its role.

CRANBERRY HARVESTING IN CHATSWORTH, BURLINGTON COUNTY

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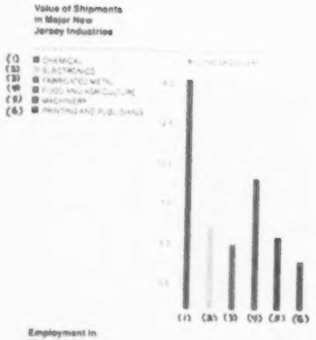
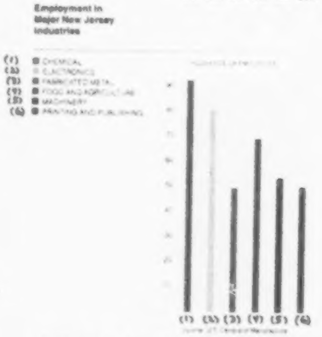
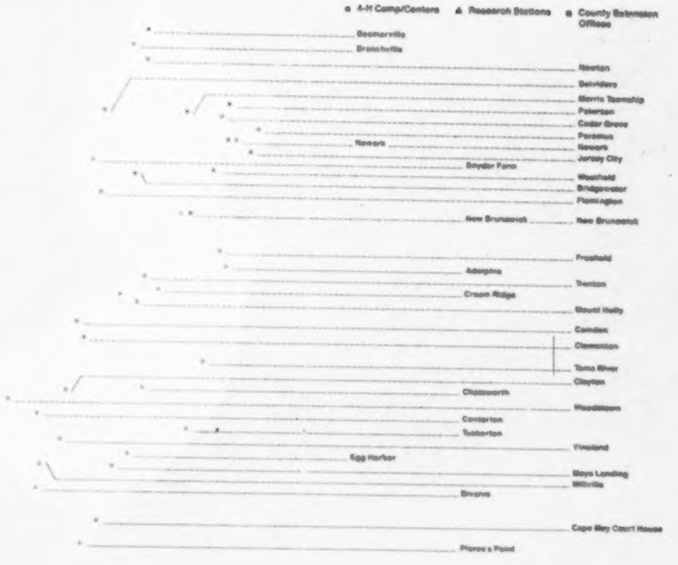




Numbers in parentheses refer to charts above:

(1) Chemical. (2) Electronics. (3) Fabricated metal. (4) Food and Agriculture.
(5) Machinery. (6) Printing and Publishing.


● 4-H Camp/Centers
▲ Research Stations
● County Extension Offices
Beemerville
Branchville
Newton
Belvidere
Morris Township
Paterson
Cedar Grove
Paramus
Newark
Newark
Jersey City
Snyder Farm
Westfield
Bridgewater
Flemington
New Brunswick
New Brunswick
Freehold
Adelphia
Trenton
Cream Ridge
Mount Holly
Camden
Clementon
Toms River
Clayton
Chatsworth
Woodstown
Centerton
Tuckerton
Vineland
Egg Harbor
Mays Landing
Millville
Bivalve
Cape May Court House
Pierce's Point

Food, Agriculture, and Related Industries Supported by the New Jersey Agricultural Experiment Station

	Value of Annual Shipments and Receipts in Millions of Dollars	Number of Employees
Agricultural Production	583	28,121
Food and Kindred Products	8,041	38,234
Wood, Paper, Textile Mills	1,509	20,600
Agricultural Support	256	8,788
Food, Agricultural Wholesale Trade	4,020	8,984
Food, Agricultural Retail Trade	609	9,016
Subtotal	**15,018**	**114,758**

Other Industries Supported by the New Jersey Agricultural Experiment Station

Pharmaceuticals, Medicinals, Biologicals	4,347	31,500
Selected High Technology Services	1,287	23,329
Selected Leisure and Recreation Services	2,481	47,502
Subtotal	**8,116**	**102,331**
[illegible]	23,133	217,089

Source: U.S. Census of Manufactures and U.S. Census of Service Industries

BLUEPRINT FOR THE FUTURE

Rutgers University and the station today have an opportunity to become the primary technical assistance arm of New Jersey's state and local agencies. Toward that end, a new strategic plan named Vision 21 has been developed to foster academic and scientific excellence at Cook College and the station. Realization of the goals of Vision 21 will bring the station to the level of excellence it must attain in order to meet the variety of critical tasks set for it in the twenty-first century.

The plan seeks to build excellence in the faculty, strengthen basic science to work toward solving the state's food, agricultural, and environmental problems, and enhance the role of Rutgers Cooperative Extension in research and communication.

LOOKING AHEAD

Vision 21 sets priorities for the station's research and service programs. It calls for the concentration of new resources in key areas. These include: intensive production agriculture to maximize economic return for New Jersey farmers; food technology to benefit the state and national food industry through research in such fields as food microbiology and nutrition; and marine and coastal sciences to meet the needs of New Jersey's fishing and recreational industries.

Also included are: environmental research to address both quality of life concerns and our finite natural resources; advances in biotechnology to improve agriculture and the environment; and policy and socioeconomic studies to assess the impacts of scientific research and development, explore marketing issues, and determine sound food and agriculture policies.

The timing for this new plan could not be better. The state has undertaken complementary efforts in hazardous and toxic substances management, coastal zone management, the mitigation of the impacts of development, and other public issues closely related to the work of the station.

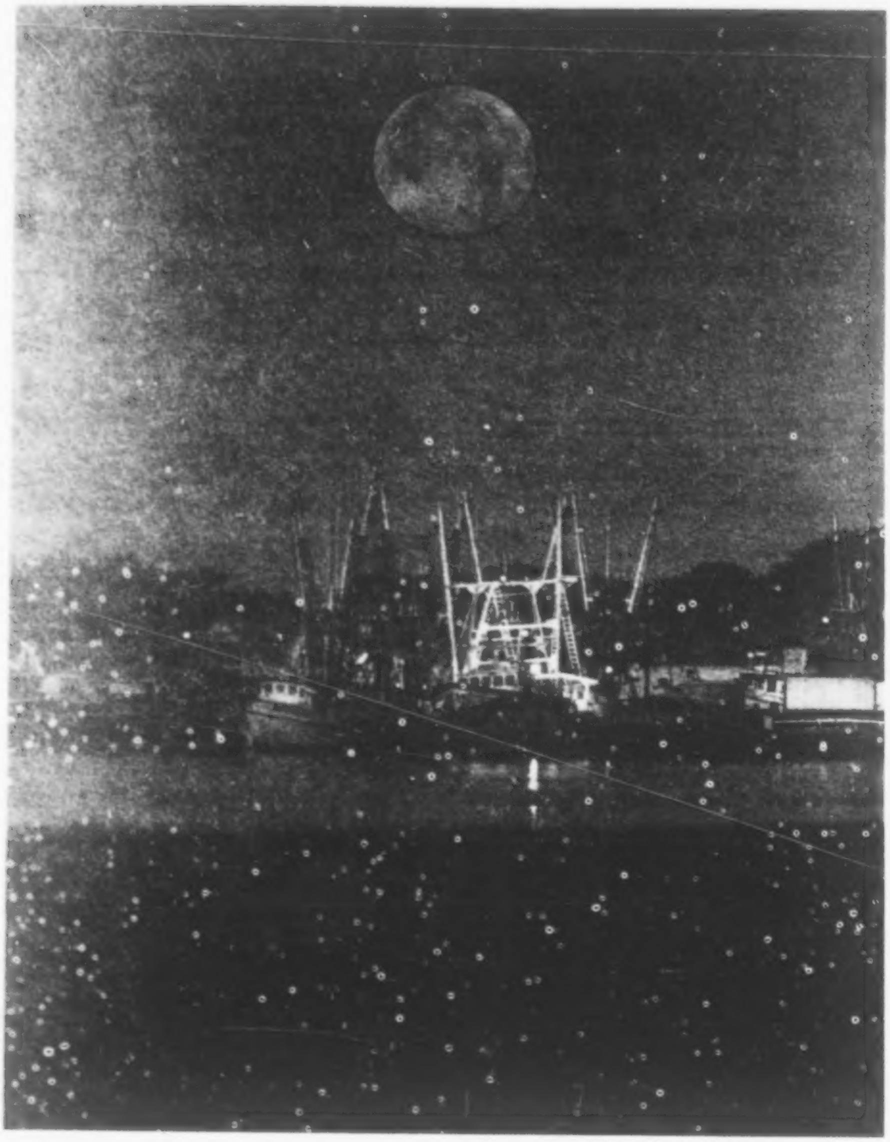
THE NEED FOR SUPPORT

But before the goals of Vision 21 can become reality, before the station can work at full capacity to meet the challenges of the future, a major investment is needed to build and renovate facilities, to acquire equipment, and to hire and support new faculty.

There has not been a broad base of specific state support for a comprehensive building program for major new research facilities at the station in the modern era of its long and distinguished history. Only two major new research facilities—the Food Science Building and environmental science laboratories—have come into use by station scientists since 1949.

Years of chronic underfunding of the station's operating budget, as well as the deterioration of its physical facilities, have had a combined effect so acute that there is now a crying need for new state assistance for the station.

Such support for faculty and research programs, continuing education efforts, and other necessary components will also provide the finest possible teaching and research environment for the training of the young men and women who will play leading roles in assuring the health and vitality of New Jersey's people and economy in years to come.



CAPE MAY INLET, CAPE MAY COUNTY

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Close cooperation between Rutgers, the station, and the New Jersey Commission on Science and Technology have resulted in the creation of new high-technology centers of excellence at Cook College. These focus on advanced food technology and agricultural molecular biology. With the proposed new Institute for Marine and Coastal Sciences, they will link the station and Rutgers with the corporate and industrial community to address the various needs of the people and economy of the state.

FOOD TECHNOLOGY

The work of the new Center for Advanced Food Technology (CAFT) will strengthen joint research and development programs important to the food industry as a whole, offer scientific education, and provide entrepreneurial assistance.

CAFT is the world's only industry-university cooperative venture committed to interdisciplinary generic food research. The center is studying the role of water in the manufacture and storage of foods, developing measurements for continuous monitoring of food products during processing, and expanding the understanding of the extrusion cooking method used to produce cereals, snacks, pasta, and pet foods. The center unites the food industry with station researchers and other scientists from such disciplines as food science, chemistry, microbiology, physics, and applied mathematics.

Station food science programs have developed food packages ranging from those used by NASA astronauts to plastic soda containers. Here, canned foods are sorted prior to thermal processing in the course of a safety test.

AGRICULTURAL MOLECULAR BIOLOGY

A new initiative in biotechnology and plant sciences will address state and national needs in developing superior plant varieties. These facilities will also eliminate the need for New Jersey agricultural industries to rely on scientists in other states for basic research programs and consultation in molecular biology. The creation of the Center for Agricultural Molecular Biology (CAMB) at the station is important in coordinating Rutgers' efforts in biotechnology research. It will also allow the university to provide needed expertise close to where corporate decisions are made.

CAMB, designed to be one of the world's largest and most sophisticated plant research centers, will apply genetic engineering and related biotechnology to benefit the food, farm, and agrichemical industries. Applications of new molecular technology will speed improvement in the efficiency of plant and animal product development. The technology will be incorporated into conventional plant breeding programs, remedy environmental pollution problems, and expand understanding of fundamental life processes. The center will cooperate with Rutgers' Waksman Institute of Microbiology and the New Jersey Center for Advanced Biotechnology and Medicine, as well as with the state's growing biotechnology industry.

Computer modeling, here showing an anxiety-reducing drug, is an established technique in agricultural as well as medical research. CAMB will use modeling in studies of herbicidal and insecticidal compounds, among others, and in the development of new formulations.

MARINE AND COASTAL SCIENCES

The Institute for Marine and Coastal Sciences (IMCS), presently in its planning stages, will provide a much needed focus for strategies addressing the environmental quality of the coastal zone, develop methods to identify and trace pollution, and support fisheries in threatened environments.

The most urgent task for the IMCS will be to arrest the alarming decline in ocean water quality. This institute will also provide cohesion and direction to the fisheries industry and support to New Jersey companies that process and market finfish and shellfish. Commercial and recreational fishing contribute about $1 billion annually to the economy and account for some 10,000 jobs in the state. Additional goals for the IMCS include revitalizing the oyster and hard clam industries and promoting the use of underutilized species.

New Jersey's coastal wetlands, including the Brigantine National Wildlife Refuge, are among the areas of research emphasis planned for the station's new Institute for Marine and Coastal Sciences.

LONG BEACH ISLAND OCEAN COUNTY

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SOURCES OF FUNDING

The committee has developed a broad financial strategy for the station that provides funding from a variety of sources. With the state seen as taking a leadership role, the strategy calls for sharing the overall cost through productive partnerships with:

- The government of the state of New Jersey, to increase funding for the station's operating and capital needs in the annual budget and to continue support by the New Jersey Commission on Science and Technology.
- General obligation bond issues approved by New Jersey voters.
- Increased general support and grants from the federal government, especially through the U.S. Department of Agriculture.
- The participation in experiment station funding by agencies concerned with New Jersey's marine and coastal environments.
- Bonded debt incurred through Rutgers' Fund for Distinction.
- Contributions by agricultural commodity interests and other clientele of the station.
- Corporate support.
- Support by foundations and private donors.

What can we expect in return for such an investment? In the simplest economic terms, a recent national study conducted in another state shows that $1 million spent on public agricultural research added $9 million to agricultural output and $11 million to the gross state product. It also generated enough work to give 300 people jobs for a year. There are no comparable rates of return in the private sector.

Focus on Need Adoption of this financial strategy will enable the station to address many of the problem areas New Jersey must face in the future. In addition to support for the new advanced technology centers, the strategy will provide necessary funding for a major new plant and life science building with a state-of-the-art greenhouse complex, new facilities for programs in environmental and natural resource sciences, a new small animal care facility to meet national animal welfare standards, and renovations to buildings in New Brunswick and the station's field locations throughout the state.

Capital Investment The cost of providing these facilities over the next five years is estimated to be $156.1 million, which includes new construction, renovation, and equipment. To date, $77.1 million of that amount is either in hand or anticipated from Rutgers, the proposed state bond issue, and other sources. This leaves a goal of $79 million in new funding required to meet the capital needs of the station.

Operating Costs In addition, the state-funded operating budget for the station will have to more than double over the next five years, from the current level of $17.7 million to about $44.6 million annually. This is the source of salary and other support for the people who will work in these new facilities and is an essential complement to the capital support requirements.

The station's specific capital and operating needs are detailed later in this report. Potential sources of the necessary monies are identified in the following thirteen recommendations.

THE STATE'S ROLE

1. The committee urges that the state legislature and the voters of New Jersey approve Governor Kean's recommended $350 million Jobs, Education, and Competitiveness Bond Issue, which will provide the New Jersey Agricultural Experiment Station with $37 million for presently unmet construction costs in New Brunswick and South Jersey.

2. The state of New Jersey is called upon to increase the operating budget of the New Jersey Agricultural Experiment Station over the next five years from the current $17.7 million to $44.6 million annually.

3. The committee recommends that the state provide, in its annual capital budget, appropriations totaling $28.3 million for capital construction and equipment needs at the station over the next five years. The committee also recommends that the New Jersey Commission on Science and Technology provide an additional $1 million in equipment support.

THE FEDERAL GOVERNMENT'S ROLE

4. The New Jersey delegation to the U.S. Congress is urged to support approval by the federal government of $37.2 million in capital support for the plant sciences building and the Center for Agricultural Molecular Biology, based on a feasibility study already funded by the U.S. Department of Agriculture.

5. The federal government is encouraged to provide additional competitive grant programs for experiment stations that meet critical state and national needs so that the New Jersey Agricultural Experiment Station can continue to increase its competitive grants and contracts.

OTHER AGENCIES

6. The committee recommends that government agencies concerned with the protection of the marine environment provide $9 million in support of the proposed Institute for Marine and Coastal Sciences.

UNIVERSITY PARTICIPATION

7. Rutgers University is urged to continue to provide support for the experiment station's needs under the Fund for Distinction.

8. The committee recommends that the university continue incentives to encourage faculty members to seek available federal grant and contract support for research at the New Jersey Agricultural Experiment Station.

9. The committee encourages the university to continue to enhance the undergraduate and graduate instructional programs of Cook College and strengthen their relationships with the New Jersey Agricultural Experiment Station.

PRIVATE SECTOR SUPPORT

10. The committee calls upon industry in New Jersey and in the metropolitan region to recognize the importance of the New Jersey Agricultural Experiment Station and support it through capital and equipment gifts and ongoing research grants. The committee has thus far identified at least $3.5 million in immediate experiment station needs for which such support would be appropriate.

11. Commodity groups and other organizations aided by the programs of the New Jersey Agricultural Experiment Station are encouraged to support financially the research of which they are direct beneficiaries.

12. The committee calls upon the station, with assistance from the Rutgers University Foundation, to seek more aggressively foundation and individual support from those interested in and benefiting from work in the areas the station addresses.

PUBLIC AWARENESS

13. The university, Cook College, and the station should take additional steps to increase public awareness of the station and its services and potential contributions to the state.

FACILITIES AND RESEARCH

Careful study of the capital needs of the station shows clearly that a number of capital projects are required in order for the station to fulfill its mission in meeting New Jersey's challenges of change.

The Vision 21 strategic plan sees some key areas for research and service by the station that will yield great social and economic return on new investment and pay enormous dividends to the people and economy of New Jersey. The committee has identified the following new capital projects as necessary if the station is going to be able to meet these goals:

- A *Plant and Life Science Building* for departments working in plant pathology, horticulture and crops, and entomology. The building will house nearly 250 faculty and staff and will also include a research library and classroom facilities. The estimated cost of the project is $45.4 million.
- The *Center for Agricultural Molecular Biology* will accommodate sixteen research programs located in close physical proximity to the Plant and Life Science Building. This facility will house approximately 160 people and is expected to cost $29 million.
- *State-of-the-art greenhouses* are required to support the plant science research program and replace antiquated facilities now in use. A new greenhouse complex, including a head house with two small laboratories and a growth chamber facility, will cost an estimated $7.2 million.
- The *Institute for Marine and Coastal Sciences* will emphasize research related to the development of New Jersey's marine industry and the maintenance of coastal estuaries and wetlands. It will accommodate ten lead scientists and a staff of approximately 100 people. Anticipated cost is $23 million.
- An addition to the Food Science Building, already under construction, will provide laboratory and office space for the new *Center for Advanced Food Technology*. This project will cost $10.7 million.
- A new facility to house the station's programs in *environmental and natural resource sciences* is already under construction. This will cost $11.1 million.
- Renovations are needed for antiquated and inadequate facilities in *Thompson Hall*, presently housing the nutrition department, and *Lipman Hall*, presently housing biochemistry and microbiology. These will cost $4.2 million.
- A new *Small Animal Care Facility* is desperately needed to provide the station with a facility meeting national scientific standards. The anticipated cost is $3.8 million.
- Renovations and additions are needed for *field stations throughout the state*, including Bridgeton for vegetables and nursery crops, Oswego for blueberries and cranberries, Cream Ridge for fruit, and Bivalve for shellfish. These will cost $21.7 million.

Cloning techniques have been important to the station's research efforts in plant breeding. Among the breeding program's recent accomplishments are two new asparagus varieties.

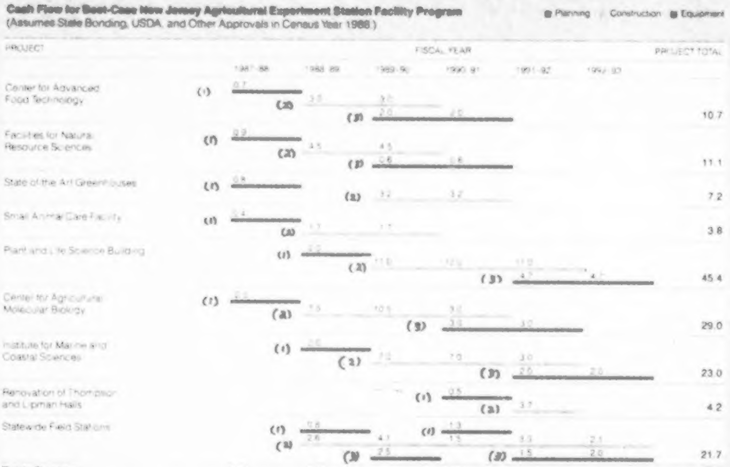
Projection of Additional Capital Requirements for the New Jersey Agricultural Experiment Station (Expressed in Millions of Dollars)

	CONSTRUCTION COSTS					EQUIPMENT COSTS		
	Authorized		Anticipated			Anticipated		
PROJECT	Rutgers	New Jersey Commission on Science and Technology	Rutgers	Proposed 1988 State Bond Issue	Additional Unmet Requirements	New Jersey Commission on Science and Technology	Additional Unmet Requirements	**Total Project Costs**
Center for Advanced Food Technology	0.7	6.0	–	–	–	4.0	–	**10.7**
Facilities for Natural Resource Sciences	7.8	–	2.1	–	–	1.2	–	**11.1**
State-of-the-Art Greenhouses	0.8	–	–	3.2	3.2	–	–	**7.2**
Small Animal Care Facility	3.0	–	0.8	–	–	–	–	**3.8**
Plant and Life Science Building	–	–	2.0	6.8	27.2	–	9.4	**45.4**
Center for Agricultural Molecular Biology	–	–	–	17.0	6.0	–	6.0	**29.0**
Institute for Marine and Coastal Sciences	–	–	10.0	–	9.0	–	4.0	**23.0**
Renovation of Thompson and Lipman Halls	0.2	–	1.5	–	2.5	–	–	**4.2**
Statewide Field Stations	–	–	–	10.0	5.7	–	6.0	**21.7**
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Prospective Sources of Funds for Unmet Capital Needs of the New Jersey Agricultural Experiment Station (Expressed in Millions of Dollars)

	SOURCES FOR UNMET CONSTRUCTION COSTS				SOURCES FOR UNMET EQUIPMENT COSTS				
	Other State Appropriations	Federal Government	Other Agencies	**Unmet Construction Total**	Other State Appropriations	Corporate Contributions	Federal Government	New Jersey Commission on Science and Technology Operating Appropriations	**Unmet Equipment Total**
State-of-the-Art Greenhouses	3.2	–	–	**3.2**	–	–	–	–	**–**
Plant and Life Science Building	–	27.2	–	**27.2**	8.4	1.0	–	–	**9.4**
Center for Agricultural Molecular Biology	–	6.0	–	**6.0**	–	1.0	4.0	1.0	**6.0**
Institute for Marine and Coastal Sciences	–	–	9.0	**9.0**	3.5	0.5	–	–	**4.0**
Renovation of Thompson and Lipman Halls	2.5	–	–	**2.5**	–	–	–	–	**–**
Statewide Field Stations	5.7	–	–	**5.7**	5.0	1.0	–	–	**6.0**
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Cash Flow for Best-Case New Jersey Agricultural Experiment Station Facility Program
(Assumes State Bonding, USDA, and Other Approvals in Census Year 1988.)



	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	
Total: Planning	4.2	4.8		1.8			
Total: Construction	0.6	19.3	45.0	26.7	21.0	2.1	
Total: Equipment			5.1	5.6	11.2	8.7	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Numbers in parentheses refer to the table above.
(1) Planning. (2) Construction. (3) Equipment.

BEST AVAILABLE COPY

MAINTENANCE AND SUPPORT

Operating funds for the station's research and extension programs include salary and nonsalary needs and operation and maintenance funds for buildings and equipment. Over the next five years a $26.9 million increase in salary and operating funds will be needed. In addition, one-time supplemental appropriations of $11.8 million are also needed for equipment replacement ($2 million) and to properly equip the laboratories of new faculty ($9.8 million).

TOWARD EXCELLENCE

The station has been summoned to become one of the best in the nation. To achieve that goal, the current budget base must be increased to bring station programs up to a funding level comparable with that of leading agricultural experiment stations in the country. For New Jersey we project that level to be approximately $160,000 per researcher. This figure includes a competitive salary for the scientist, plus technical support, and an operating budget.

KEEPING PACE WITH INFLATION

Because it is difficult to predict inflation, the figures are reported in 1988 dollars. The committee anticipates that inflation would be added to the annual budget request as justified. An inflation rate of 5 to 7 percent per year during the next five years would be realistic, given the historical pattern of inflation in scientific research. Increases in the salary base resulting from negotiated merit increases and cost of living adjustments have also not been included in these budget estimates.

The accompanying chart illustrates these needs.

Impact of Dollars Required to Implement Vision 21 on the New Jersey Agricultural Experiment Station (NJAES) Annual Operating Budget Between Fiscal Years 1989 and 1994

(Expressed in Millions, 1988 Dollars)

	FISCAL YEAR					
	1989	1990	1991	1992	1993	1994
New Dollars for NJAES Annual Operating Budget[1]						
Research and Extension	2.5	6.6	10.6	13.5	15.9	19.4
Advanced Technology Centers	1.1	3.8	5.8	6.8	7.5	7.5
Total New Annual Operating Dollars	**3.6**	**10.4**	**16.4**	**20.3**	**23.4**	**26.9**
One-Time Supplemental Appropriations – Operating[2]	4.0	2.5	1.7	1.8	1.8	–
One-Time Supplemental Appropriations – Capital[3]	2.0	–	6.0	12.7	9.6	–
Total New Dollars Needed	**9.6**	**12.9**	**24.1**	**34.8**	**34.8**	**26.9**
Current 1988 Operating Budget Base[4]	17.7	17.7	17.7	17.7	17.7	17.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

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VISION 21 :

A Strategic Plan For Cook College
New Jersey Agricultural Experiment Station

October 15, 1987

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PREAMBLE

This planning document is not intended to educate the reader as to the intricacies of the land-grant mission, federal and state responsibilities, federal mandates, and budgetary constraints under which Cook College/NJAES operates. Nor is it intended to explain our network of political and program involvement at the local, state, federal, and international levels.

This document reflects an assessment of the opportunities afforded Cook/NJAES and outlines a plan to build on those opportunities to achieve excellence in the agricultural, biological, environmental and life sciences, and beyond that, to secure for Rutgers, The State University of New Jersey, premier status among the land-grant institutions into the next century. The plan can only be effective if Cook/NJAES and the University have leaders with common vision, a faculty dedicated to excellence in research, teaching and extension, college and department level structures that ensure discipline strength and multidisciplinary communication, and substantial funds for capital improvements and equipment acquisitions. The strategy is based on present strengths and anticipated trends in societal needs and as such will continually evolve as conditions change.

INTRODUCTION

Relative to sister land-grant universities and their natural resource components, Cook College/NJAES is exceptionally well-positioned to assume national leadership in its education, research, extension and international programs. Cook/NJAES has anticipated the evolution of problems facing modern agriculture and has integrated new technologies and broadly based perspectives with traditional food, agricultural and environmental sciences; many other universities are just now attempting to emulate our accomplishment. As a result, pioneering instructional programs have developed and attracted an exceptionally high quality student body, comprising the third largest college of agriculture and natural resources in the U.S. The research and extension programs have served well the interests of the university and the state. However, to take advantage of emerging opportunities to meet widely recognized needs, and to fulfill the Governor's mandate for excellence, Cook/NJAES, as part of Rutgers University, must strategically assemble its programs to create the conditions necessary to strengthen faculty excellence and program leadership, and to mobilize resource support adequate to the task with the assistance of the state, the university, and private and corporate entities. When accomplished, these conditions will permit development of our full potential and propel Rutgers University into the small circle of premier and influential land-grant universities. Among the colleges and programs at Rutgers Univeristy, Cook College/NJAES is best prepared to effect that effort.

The design and implementation of this plan is predicated on the changing dimensions of the food, agriculture, and natural resource systems in New Jersey, the nation and the world. By virtue of changing economic forcec, evolving clientele, urban and industrial development, emerging technologies, increased environmental sensitivity, consumer expectations, and new federally-funded initiatives, the direction of Cook/NJAES programs must change dramatically. Land-grant universities must modify production and commodity oriented programs and expand the definition of the food, agriculture, and environmental sciences to include most of the biological and life sciences, that influence significantly food, fiber, and human health and well-being. This redefinition is already being reflected in a substantial redirection of federal initiatives and resources into the basic sciences. It is crucial that we strengthen our basic science capabilities and enhance the synergy between the basic and applied sciences in traditional as well as in new areas of emphasis. These activities will enhance and will not, in any sense, diminish the ability of Cook/NJAES to meet the needs of its traditional clientele.

It is upon this threshold that Cook/NJAES stands. To meet new challenges, Cook/NJAES must position itself to secure high quality leadership, improved organizational structure, enhanced faculty expertise, and state-of-the-art facilities and equipment. Cook/NJAES with its relatively small faculty must also identify its strengths and capitalize on those areas where opportunities for future prominence exist.

POSITIONING

How Achieved

For Cook/NJAES to achieve excellence, it must be properly positioned. To that end, a series of objectives are identified that if achieved would put the college in a position to achieve excellence in a rapid fashion and minimize constraints that would hinder the process. For this plan to succeed, the following objectives must be supported by the university administration, Cook/NJAES administrators and faculty, as well as traditional and new clientele.

1. Build strength in the basic sciences that will support the applied programs and will lead to excellence in research, teaching and extension. This objective must be pursued broadly and not simply concentrated in a few centers of excellence.

2. Facilitate the integration of the basic and applied sciences into mission-oriented, disciplinary as well as multidisciplinary approaches to solving complex problems facing modern agriculture and the environment. Integration must be accomplished within departments as well as college-wide, with special attention given to the relationship between centers and the college departments. These relationships will ensure that Cook/NJAES will continue to meet the needs of traditional production agriculture and the environment.

3. Foster an atmosphere and administrative philosophy that attracts, encourages, and rewards faculty excellence.

4. Attract and reward outstanding leadership at all administrative and program levels.

5. Establish an administrative structure and departmental composition that fosters communication and interaction.

6. Maintain an ability to assess and respond to evolving societal needs through strategic planning and budgetary flexibility.

The following describes in a broad sense the changes proposed in research, teaching, extension, and international programs.

Research

The experiment station will refocus its philosophy and modify its operation. We propose to view the station as a funding agency with projects determined by mission relevance and program emphasis, and evaluated for technical merit by peer review. While individual projects will remain the mainstay of NJAES funding, increased emphasis will be given to multi-investigator, multidisciplinary research projects that may draw on scientists and expertise from any campus or state agency, as well as from Cook/NJAES.

With respect to the college, we will promote increased faculty initiative and self-sufficiency. We will promote an awareness of the research component of IDR support and extramural funding opportunities, and encourage assertive entrepreneural activity in the disciplines and decreased dependence on NJAES resources for substantial program support. Additional support for the NJAES will be aggressively pursued from state, commodity/user groups, and industry sources. Basic research will be strengthened by hiring outstanding new faculty with postdoctoral experience when appropriate to enhance faculty expertise. Incentives such as funding and sponsored study leaves will be made available to enable faculty to remain at the forefront of rapidly evolving fields.

Teaching

The academic programs of the college will be continually refined and, as merited, redirected to meet emerging needs. Curricula will emphasize the new techologies as well as the retention of traditional programs for which a sustained demand is demonstrated. In several instances, the plan addresses specific changes resultant, in part, from external reviews and from the general evolution of respective discipline areas.

Two review structures (processes) provide regular advice and consultation on curriculum: the external review process of the University and the USDA-CSRS departmental review program. Although these have served well in the past to provide evaluations and suggestions for future curricular modifications, in some instances it may be appropriate to establish a special review process utilizing consultants external to the University to assist a curriculum faculty in the review of its current offerings and to aid in planning for new direction.

Although the plan calls, in some instances, for some restructuring of departments, this should not be construed as actions which will in and of themselves drive curriculum change. To the contrary, curriculum revisions are envisioned as evolutionary in nature responsive to gradual trends in disciplinary directions, societal/employment demands, and the emergence of new interdisciplinary areas, and must be faculty driven.

A sustained effort will be mounted to ensure that those courses required by the faculty—yet offered by other faculty of the University—are available to Cook students on a regular basis. In those intolerable instances where there are perceived or real barriers to the enrollment of Cook students in these courses, immediate resolution will be sought.

Consideration will also be given to the offering of Cook minors and certification programs on a space availability basis to students enrolled in other New Brunswick colleges.

Care will be taken in the recruitment of new faculty personnel to attract those individuals to the faculty who hold not only significant credentials of research and scholarship, but also exhibit a commitment to undergraduate and graduate instruction.

Aggressive recruitment of high quality students will receive renewed emphasis. Utilizing new tools (video presentations, Cook College brochure, etc.) at both on campus recruitment sessions as well as presentations off campus, at invited lectures in high schools, at 4-H clubs, community events, etc., will be expanded. The focus of these activities will not be singularly to increase the applicant pool for the college, but rather to attract the most outstanding of the high school graduates to the traditional and new programs of the college. Particular attention will be given to recruitment and retention of minority and disadvantaged students.

Student retention efforts will be focused more precisely to identify potential leavers and, where appropriate, to provide increased counseling and other academic and nonacademic support mechanisms and programs to assist students with those difficulties encountered in the academic environment. The HELP program instituted on a pilot basis during the 1985/86 year will form the foundation of this program effort.

The Professional and Continuing Education Program of the college has for decades provided to the consumer population beyond the campus new knowledge to assist them in the professional, occupational, and avocational pursuits. From the "high technology" courses of DNA techniques to the "home gardeners" programs, the scope of the programs is anticipated to expand to an increasingly diverse clientele consistent with the ever important public service component of the mission of the college and experiment station.

Extension

Cooperative Extension will build upon its existing strong base by becoming more efficient in the utilization of its personnel through use of state-of-the-art communication systems including computer interactive data bases, teleconferencing, video tape development and use, and printed materials. Extension will become more involved in applied research. Where appropriate, selected agents will conduct applied research and will be provided with technical support as required. Extension specialists will become more knowledgeable and articulate in the basic sciences. Limited Extension faculty participation in the college teaching programs will be encouraged to an extent that will not impair performance of extension duties. Split appointments with teaching faculty on a specific reciprocal basis will be assigned when it is mutually beneficial to both programs. Faculty on all split lines will be held accountable to insure that an appropriate amount of time is devoted to assigned activities. Cooperative Extension will continue to extend its sphere of influence to more diverse clientele, e.g., the marine industry, municipal officials, etc.

International Program

The benefits of a commitment to international activities have been long recognized by the premier land grant universities, whose ranks we seek to join. The Cook/NJAES international program is poised for major expansion. Project accomplishments in Central America and the Caribbean (notably in Panama) are attracting increased external financing; and opportunities in other developing and developed regions of the World will be explored in the years ahead. Major new thrusts are imminent in natural resources management, intensive horticultural and livestock production, food technology, and marine resources. Increased faculty involvement will be pursued through a new incentive policy approved by the university, which provides significant resources in support of departmental research programs, and through similar mechanisms which will enhance the international dimensions of Cook/NJAES teaching and extension activities.

PROGRAM THRUST AREAS

Relative to the strategic projection of agricultural and natural resource activities of Cook/NJAES, this plan contains at its core a series of select program thrust areas targeted to receive major emphasis for resource commitments. The selection of these thrust areas was based on: 1) a desire to build upon existing faculty strengths, 2) the changing face of agriculture, 3) projected societal needs, 4) an assessment of problems facing agriculture and the environment, 5) an assessment of opportunities to exploit developing technologies, and 6) the potential for Cook/NJAES to establish preeminence. The listing of thrust areas below, while discussed in the following sequence, does not infer in any sense a priority ordering:

- Intensive Production Agriculture
- Food Science and Nutrition
- Marine and Coastal Sciences
- Environment
- Biotechnology
- Policy and Socioeconomic Impact

Each program thrust area described in this section is discussed in terms of the "what and why" being proposed; issues of "how" are addressed in the implementation section that follows.

Each thrust area will be coordinated by an advisory committee. These advisory committees will be chaired by an associate director/NJAES when a NJAES institute or center is involved, and otherwise by a person appointed from within the committee. The role of each advisory committee will be: 1) to coordinate teaching, research and extension programs in the respective thrust area; 2) to coordinate the NJAES centers and institutes with related Cook/NJAES departments and curricula; 3) to develop short and long-term strategic plans, including an assessment of needs and priorities with respect to programs, personnel, capital facilities and equipment; 4) to identify and exploit opportunities to procure external funds; and 5) to advise the NJAES Senior Associate Director and the Dean/NJAES Executive Director as to program priorities and budgets.

INTENSIVE PRODUCTION AGRICULTURE

New Jersey is among the most rapidly urbanizing states in the nation. As a result in increased land values, tighter regulatory actions and the effects of a crowded environment, acreage is declining for production agriculture. This thrust area, including both plant and animal production, will address this issue by developing intensive agricultural systems that while being environmentally sound, will enhance production, increase efficiency and maximize economic return on the available land.

Leadership. An advisory committee consisting of the chairmen of Horticulture and Crop Science, Animal Science, Agricultural Economics, Biological and Agricultural Engineering, Plant Pathology, a Cooperative Extension rep resentative, and an appropriate college curriculum coordinator will lead this thrust area.

Faculty. In addition to the existing agricultural production programs, a number of changes are envisaged. Consistent with external reviews, areas of emphasis in the new Department of Horticulture and Crop Science will include an expanded world-renowned turf research and instructional program that reflects the importance of this industry. The nationally and internationally prominent NJAES program in greenhouse technology will be expanded to include a larger number of crops with emphasis on energy, water, and light-efficient crop cultivars and more automated production systems. Emphasis also will be placed on maintaining postharvest quality and extending shelf life. The international program will need additional lines to develop its horticultural program in Central America. Needed expertise in plant breeding and genetics to exploit advances in plant bioscience and the development of cultivars for intensive agricultural systems will be provided through redirection of current resources and by establishing an applied genetics program within the Cook/NJAES departments. Expertise in animal production research in the Department of Animal Science will be increased by cooperation with other states by the extension specialists. It is recognized that international livestock production is predominantly extensive; faculty with expertise in this area will be required if Cook/NJAES is to make contributions to livestock production in tropical countries.

Facilities. A new science building will provide needed laboratory and classroom facilities. New greenhouse and growth chamber facilities will be constructed. As recognized by the Kennedy report, the redirected horticultural research effort will require additional plot land.

Projected animal science research programs will require renovated large animal and new small animal research facilities.

Equipment. The expanded research facilities will require laboratory equipment, as well as standard and specialized farm equipment.

Undergraduate and graduate programs. Following reorganization, undergraduate and graduate programs in horticulture/plant science and animal science will be evaluated and redirected to reflect the new emphasis in this thrust area.

Interactions. Because of the broad nature of this thrust area, there needs to be interaction among all Cook/NJAES departments as well as with other universities, industry, and governmental agencies such as the New Jersey departments of Agriculture and Environmental Protection.

__Communication__. Continuing and professional education programs will be enhanced for both domestic and international clientele. Short-term consulting services will be needed in the international program to provide developing countries with expertise necessary to utilize tissue culture techniques for the improvement of crop cultivars.

FOOD SCIENCE AND NUTRITION

Cook/NJAES has a strong program in food science that supports an $8 billion food industry, the second largest industry in the state. We anticipate that the Department of Food Science will continue to have a premier role at Cook/NJAES in support of this industry. The Center for Advanced Food Technology (CAFT) will form a strong interface with industry to study basic principles in food processing. The expanded Nutrition Department will provide basic nutrition and metabolism input to food problems. The areas of postharvest, postslaughter and postcatch technology, sensory and nutritional quality, food safety, product and process development, and packaging will be developed under this thrust through cooperation with other departments at the Cook and Busch campuses. This thrust area will also address food issues related to human health and well being.

__Leadership__. This thrust will be coordinated by an advisory committee, consisting of the director of CAFT and the chairs of the departments of Food Science, Nutrition, and Home Economics Education an Extension Home Economist, and an appropriate college curriculum coordinator. The director of CAFT will also serve as Associate Director for Food Science and Nutrition/NJAES.

Faculty. Six additional faculty researchers to be employed by CAFT are anticipated. The areas of postharvest physiology, processing, and nutritional quality will be supported by redirection of lower priority programs, by judicious faculty replacement in the Department of Horticulture, and by closer collaboration with the Agricultural Research Service, Postharvest Research Laboratory. Additional faculty in Cooperative Extension and a new emphasis by county extension home economists will be required to bridge the gap between basic research and industrial product development, as well as between product development and consumer acceptance. CAFT plans include the development of a food TEX Center. International expertise will be needed to develop and apply appropriate technologies in the areas of food processing, quality maintenance, and packaging for worldwide export, as well as in our USAID-funded Central American program.

Facilities. With the completion of the CAFT annex and the planned renovation of Thompson Hall, research and office facilities will be adequate. Additional classrooms and teaching laboratories will be required.

Equipment. With the infusion of funds through CAFT, this program is well equipped for research. Special equipment for expanded postharvest studies must be obtained. Cooperative Extension will require additional computer capabilities in order to meet the need to communicate with and service the food industry. The undergraduate teaching programs will require some high technology equipment and instruments to continue to ensure state-of-the-art training for students.

Undergraduate and graduate programs. The programs in food science and in nutrition are recognized for their current strengths, and continual evolution will occur to incorporate newly developed technologies in the curricula.

Interactions. The association between CAFT and the Department of Food Science, as well as other departments, needs to be clarified in order to define faculty, research, and teaching responsibilities. Associations between the Department of Food Science and those of the departments of Nutrition and of Home Economics will be strengthened to bridge the gap between food processing and consumer acceptance. Success in this thrust area will depend on developing strong cooperative relationships among food science, horticulture and crop science, nutrition, agricultural economics, plant biosciences, biotechnology, animal science, home economics, biochemistry, biological and agricultural engineering, chemical and biochemical engineering, mechanical and aerospace engineering, chemistry, human ecology and others both at Cook/NJAES and at other New Brunswick university campuses.

Communication. Professional and continuing education initiatives with high potential payoff for user groups and able to serve the needs of developing country professionals in their nascent food industries will be developed. To facilitate communication of technical information to user groups, a computerized information system will be developed by Cooperative Extension.

MARINE AND COASTAL SCIENCES

The marine industries in New Jersey rank third on the east coast and fifth nationally, with great growth potential. Due to the lack of a cohesive program, the marine and coastal interests in the state, both scholarly and commercially, have not approached their potential contribution to the well-being of the state. Consequently, a coordinated effort to provide strength, cohesion, and direction to the state's marine interests has begun by formation of the Center for Marine and Coastal Sciences at

Rutgers University within the structure of Cook College. This program will feature graduate teaching, research, and extension activities worthy of a major coastal state with a multimillion dollar marine industry. It is proposed that the institute become the focus and coordinator of strategies involving academic activities, commercial and industrial clientele, as well as state and interstate regulatory and development agencies. In creating one of the finest marine programs in the country, it must be recognized that a substantial portion of future research activities will be occurring in marine and coastal waters throughout the world. Such expanded research efforts will be accompanied by a marked expansion of the scope of projects associated with the international program.

Leadership. A world class center director/associate director of the NJAES for marine sciences is being recruited. This position requires an individual with international stature in marine science research and extraordinary skills in coordinating a complicated interacting program. The advisory committee for this thrust will consist of the aforementioned institute director, the research director of the institute, the chair of the newly formed Marine Sciences Department, the director of the fisheries and aquaculture TEX Center, and an appropriate curriculum coordinator.

Faculty. The establishment of the Center for Marine and Coastal Sciences and the Department of Marine Sciences on the Cook/NJAES Campus will require ten new faculty lines to be provided by the university. Because of the need for interaction between the research component and the fisheries industry, additional lines in Cooperative Extension will be required to assist the fisheries and aquaculture TEX Center.

Facilities. The center and department will require construction of a major new research facility as well as the development and expansion of similar facilities at shore locations. We will explore the possibility of research/industry cooperation in seafood processing technology.

Equipment. Major new equipment will be required to establish an internationally recognized research capability. Additional equipment will be required for applied research programs of special interest to commercial fishermen.

Graduate programs. It is anticipated that the teaching program will consist primarily of graduate studies in the marine and coastal sciences. This will be a coordinated program involving appropriate discipline areas at Rutgers University.

Interactions. The Center for Marine and Coastal Sciences has brought together under one university administrative umbrella all activities associated with marine and coastal sciences, including those currently conducted by the Center for Coastal and Environmental Studies, the Division of Water Resources, the Shellfish Research Laboratory, and the Fisheries and Aquaculture Technology Extension Center. It is envisioned that the faculty associated with the institute will include those from a wide variety of academic departments throughout the university. Extensive interactions also will occur with the departments of Environmental and Soil Sciences, Biology, Natural Resources, Human Ecology, Agricultural Economics, Geology, IR-4 and Food Science, as well as with Sea Grant Extension. Coordination and cooperation will also be required with other marine interests throughout the state, such as the New Jersey Fisheries Development Commission and the New Jersey Marine Sciences Consortium.

Communication. This initiative provides an opportunity for new professional and continuing education programs for domestic and international user groups. Greater sophistication of data bases that include marketing analysis, and weather satellite sensing for temperature and finfish migration, will be required and critical to increase the efficacy of commercial fishermen.

Statewide programs. In order to have the most effective statewide programs possible, close coordination among various commodity interests by the marine extension specialists will be required to launch needed programs in response to a potentially highly valuable industry.

ENVIRONMENT

Effective planning and management of the environment and natural resource base of the state of New Jersey presents numerous challenges and opportunities. Although small in size, the environment of New Jersey spans the full range between natural, rural ecosystems and human dominated urban ecosystems. Within these extremes, we are presented with a range of opportunities to manage our natural resource base by developing effective land, forest, water, and air quality management strategies. In addition, we are presented with the challenge of investigating a host of environmental problems that while often local in scale are of national and international concern and significance. Effectively managing growth while protecting environmental quality, integrating development into the landscape, reconciling the needs of production agriculture with environmental and resource concerns, protecting human health in the workplace and at the interface of the natural and built environments, and maintaining sustained yield and productivity of our natural resource system are complex problems. Cook/NJAES will continue to play a leadership role by developing multi- and interdisciplinary research, teaching, and extension programs to address these problems.

Leadership. By reorganizing several existing Cook/NJAES departments, two new multidisciplinary departments will be created to play a major role in solving these problems in the future. Strong chairs will be required to lead the new departments of 1) Environmental and Soil Sciences and 2) Natural Resources. This thrust area will be coordinated by an advisory committee consisting of the chairs of Natural Resources, Meteorology and Physical Oceanography, Environmental and Soil Sciences, Landscape Architecture, Human Ecology, and appropriate representatives one each from Cooperative Extension and from among the college curriculum coordinators.

Faculty. Faculty expertise will be evaluated and acquired as needed to fully develop this program area. Existing and newly appointed extension specialists will assume increased research responsibilities and apply research results to the prevention and solution of environmental problems. At the international level, the faculty will play a major role in the transfer of technology in the areas of environmental and natural resource management. Expansion in this area will require five grant-funded positions.

Facilities. Required office, research, and teaching laboratory space for both the Department of Natural Resources and components of the expanded Department of Environmental and Soil Sciences will be housed 30,000 square feet in the new Natural Resources Building currently in design.

Equipment. The research, teaching, and extension activities in this thrust area will be dependent upon state-of-the-art analytical instruments and computer technology to monitor, assess, and evaluate environmental programs and impacts. Financial support for instrumentation must be provided from both external and internal sources. University/NJAES support for data communication links and evolving hardware must be continued.

Undergraduate and graduate programs. Programs for undergraduate and graduate training will be strengthened through cooperation with other programs within Rutgers University. A policy-oriented graduate program in

Natural Resources will be initiated. A graduate program will be developed in Landscape Architecture in cooperation with other university entities, such as Urban and Regional Planning, and the expertise found in the newly formed Department of Natural Resources. The initiation of such a program will require additional faculty in Landscape Architecture. Cooperative Education placements will be used to strengthen the undergraduate academic experience.

Interactions. Success in this thrust area will require extensive interactions among a wide range of Cook/NJAES departments and programs including Marine Sciences, Microbiology, Toxicology, Horticulture and Crop Science, Plant Pathology, Entomology, Agricultural Economics, Biological and Agricultural Engineering, Agricultural and Resource Management Agents and Specialists, and Landscape Architecture.

Communications. Continuing education for people employed in environmental fields will be an important component of academic and extension activities in this area. In addition to the data bases compiled by the remote sensing center, the existing departments of Environmental Science, Meteorology and Physical Oceanography and Soils and Crops, research and extension faculty also will be responsible for establishing and managing a natural resources data base for New Jersey.

New Brunswick cooperation. Cooperation will be required between the appropriate Cook/NJAES departments and the New Brunswick university community, including the Institute for Marine and Coastal Sciences, the medical school, the Urban and Regional Planning and Geography faculties, the Ecology program, and the College of Engineering.

Statewide programs. Continuing interactions will be developed with agencies and institutions on federal and state levels, including the New

Jersey departments of Environmental Protection and Energy, the New Jersey Institute of Technology, the New Jersey School of Medicine and Dentistry, and such federal agencies as SCS, USFS, USDA, USGS, EPA, OSHA and FEMA as well as county and municipal agencies. The development of the state climatology program will be encouraged.

BIOTECHNOLOGY

The biological sciences are undergoing a revolution. With the discovery of recombinant DNA technology, it is now possible to precisely design improved plant and animal genotypes. This technology also provides a means to study basic biological mechanisms at the molecular level. However, utilization of this new technology is hindered by a lack of basic biochemical understanding of the life processes having important agricultural and environmental implications as well as unresolved social, economic, political and policy considerations. To exploit recombinant DNA technology and to insure its usefulness, a coordinated program involving the basic and applied sciences will be developed. We will integrate departmental research in animal and plant sciences with activities in the new Center for Agricultural Molecular Biology (CAMB). CAMB will provide a strong basic research presence that will backstop and augment basic and applied research in the departments.

Leadership. Leadership within this thrust area has been assured by the hiring of a Director CAMB/who has international stature, with an appreciation for the need to integrate basic and applied research to solve the complex problems facing agriculture and the environment. A chair for the new Department of Plant Bioscience with a distinguished research background in plant biology will be recruited. This thrust area will be coordinated by an advisory committee consisting of the chairs of the

Departments of Plant Bioscience, Animal Sciences, Biochemistry and Microbiology, Director/CAMB, Director of Research/Waksman Institute, and an appropriate representative from Cooperative Extension and from among the college curriculum coordinators.

Faculty. A new Department of Plant Bioscience will be established. The department will initially consist of a new chair, four new lines, and five faculty from related program areas. Since recent appointments in Animal Science have strong physiological, cellular, and molecular backgrounds, it is anticipated that only one additional appointment with genetic engineering competencies will be required by this department in this area. An opportunity exists to incorporate the microbiologists from the Busch campus into the Cook Department of Biochemistry and Microbiology. This opportunity should be evaluated as part of a program to strengthening the biological sciences at Cook/NJAES.

Facilities. Success of the program requires the renovation of Lipman Hall, and construction of a new plant/life sciences building and a building for the Center for Agricultural Molecular Biology on the Cook campus.

Equipment. State-of-the-art laboratory equipment and major new greenhouse and growth chamber facilities will be required.

Undergraduate and graduate programs. The faculty already has developed an undergraduate curriculum in Biotechnology for Agriculture in response to the foreseen initiatives in biotechnology. New courses required by this curriculum are being developed for early implementation. A strong graduate program must be developed in the plant sciences through the cooperative efforts of Cook faculty and those on other Rutgers University campuses. The development of a strong graduate program will serve to attract outstanding research faculty and graduate students.

Interactions. It is anticipated that this thrust will drive biological research at the Cook campus and as such will involve close integration of research activities in the CAMB, with departments of Plant Bioscience, Horticulture and Crop Science, Animal Science, Biochemistry and Microbiology, Environmental and Soil Science, Food Science, and Nutrition. The concentration of biomolecular research activity at this Center, constitutes a powerful science presence that will benefit Rutgers' academic programs by affording opportunities for involvement by university students, and particularly those at Cook and Douglass colleges, in this biotechnology thrust area. Moreover, success in this thrust area will depend on the close cooperation and coordination of its programs with those on the Busch campus including the Waksman Institute, the departments of Biology and Biochemistry, the Center for Advanced Technology in Medicine, and local biotechnology industries.

Communications. It is anticipated that New Jersey-based industry will benefit from information generated in agricultural biotechnology. With this development, cooperative extension will catalyze the interaction between industry and the biotechnology program. A new extension specialist in this area will be required.

When this thrust area is functionally operational, Rutgers/Cook/NJAES will be the leading center for such activity in the U.S., if not the world. This strength will undoubtedly serve to attract much federal attention related to proposed centers of technical excellence, centers for biological impact assessment, and centers for socioeconomic impact of high technology.

POLICY AND SOCIOECONOMIC IMPACT

Cook/NJAES programs in agriculture, the environment and life sciences have broad and significant impacts on individuals, families, communities, and economic systems. Moreover, in order to develop well informed policies, scientific and technical information, socioeconomic, and behavioral factors, and values must be incorporated into policy-making processes. There is a real opportunity to study the public perception and impact of emerging high technology and associated risks and benefits. We must enhance our established programs in marketing as they relate to the N. J. agricultural economy. We also will build on existing strengths involving the development and evaluation of public policies that relate to the mission of Cook/NJAES and their effective communication to appropriate constituencies and policy makers down the municipal level. For example, recombinant technology has great impact on individuals and families as well as on agriculture and the environment. It also has far-reaching ethical implications. While social and policy issues are receiving increased attention in the sphere of international development, the area of policy and socioeconomic impact is not represented prominently in other university programs involving science and technology, or research and development. Therefore, Cook/NJAES can quickly become a recognized leader in this area.

Leadership. This thrust area will be coordinated by an advisory committee consisting of the chairs of the departments of Human Ecology, Agricultural Economics, Home Economics, Natural Resources, the program leader for Risk Communication, and appropriate representatives one each from Cooperative Extension and from among college curriculum coordinators. It will be important for the chair and advisory committee of this thrust area to identify important program areas, as well as to coordinate the diverse activities which may be pursued in this area.

Faculty. In large part, existing faculty will be utilized in this thrust area. It will be necessary to enhance the policy analysis components of the departments of Agricultural Economics, Human Ecology, and the newly formed Department of Natural Resources. Three new faculty with expertise in the marine, biotechnology, and family resource management policy areas should be recruited. Faculty of the School of Urban and Regional Planning should be considered for inclusion at Cook/NJAES under the proper circumstances to enhance our capabilities in this thrust area. A new extension specialist will be hired to conduct public policy education. The international program's major initiative in natural resource management and the impact of environmental problems in developing areas will require the recruitment of additional grant-funded faculty.

Facilities. The departments of Agricultural Economics and Human Ecology already require expanded facilities to accommodate research activities. In addition, if faculty from the School of Urban and Regional Planning relocate to the Cook campus, a suitable facility must be made available.

Equipment. It will be necessary to upgrade present equipment to conduct research and disseminate information to the general public.

Undergraduate and graduate programs. The continuing importance of this area and the necessity to prepare professionals to deal effectively across the broad spectra of activities will necessitate strengthening existing options focused on policy and socioeconomic impact in the undergraduate curricula of Environmental Planning and Design, Natural Resource Management, Agricultural Economics, Human Ecology, International Environmental Studies, and the Social Strategies for Environmental Protection Certificate Program. The undergraduate program in Agricultural Economics will be refocused to provide an increased emphasis on policy development and impacts and less upon basic economic principles which can be provided by other faculties. Home Economics will place greater emphasis on family resource management. A graduate program focused in agricultural and environmental policy will be developed. There is also a pressing need to broaden existing graduate programs in the agricultural sciences to incorporate behavioral, social, and political-economic considerations, particularly in the education of overseas students.

Interactions. Due to the diversity of the programs in this thrust area, it is particularly important that cooperation continue under the direction of the program chair, among the departments of Human Ecology, Agricultural Economics, Natural Resources, Home Economics, the 4-H Department, the Humanities and Communications Unit, and those departments associated with physical and biological science programs, including the departments of Plant Bioscience, Biochemistry and Microbiology, Environmental and Soil Sciences, Food Science, Marine Sciences, and Entomology, as well as the CAMB, CAFT, and the Center for Marine and Coastal Sciences.

New Brunswick cooperation. Capabilities in this thrust area will be greatly enhanced by fostering ties with the FAS departments of Political Science, Anthropology, Sociology, Philosophy, and Economics, and with the Institute for Management and Labor Relations, the Eagleton Institute of Politics, and the School of Urban and Regional Planning.

Statewide programs. There are a number of opportunities to establish relationships between participants in thrust areas at the university and state agencies including the departments of Environmental Protection, Agriculture, and Community Affairs, the Rural Advisory Council, the New Jersey Legislature, the New Jersey Water Resources Council, and regional, county, and municipal public agencies. In addition, important international contacts will be expanded through the international research centers, and a range of international advisory councils.

IMPLEMENTATION

Implementation of the strategic plan depends on a coordinated sequence of events that is based on the availability of resources including those for faculty and faculty-support lines, for renovation of existing space and building new facilities,and for acquiring equipment. Although bricks and mortar do not make for excellence, major inputs of resources for improving physical facilities must be provided in order to attract and retain outstanding leaders and distinguished faculty.

REORGANIZATION

Nutrition/Home Economics Teaching. Those faculty in the Department of Home Economics Teaching with primary emphasis in nutrition will share joint appointments with the Department of Nutrition, but each will retain a majority portion of his or her line in Home Economics Teaching. However, these faculty will be physically relocated to offices and laboratories in Thompson Hall. Remaining Home Economics Teaching faculty will stay in Davison Hall. An outside chair with a strong background in research has been hired to head the Home Economics Teaching Department and charged to develop a strong research program. To facilitate the process, an additional research line will be provided for greater research release time. Cooperative arrangements will be established between Home Economics Teaching and Home Economics Extension that will act to strengthen both entities; and the possibility of a future merger will be seriously considered.

Entomology/Mosquito Research and Control. The Mosquito Research and Control Unit will be merged with the Department of Entomology. All statutory obligations for mosquito research will be fulfilled. Upon vacancy of the chair in Entomology, a new chair will be externally recruited.

Although facilities for the Department of Entomology are deplorable, this difficult situation will not be alleviated until relocation to a new plant/life science building.

Horticulture/Landscape Architecture Consistent with external reviews, the Landscape Architecture section of the Department of Horticulture and Forestry has been established as a separate Landscape Architecture Department with undergraduate and graduate teaching programs. A chair for this department has been selected from among its current faculty.

Environmental and Soil Sciences. A Department of Environmental and Soil Sciences will be established. The department will be composed of the existing Department of Environmental Science and seven soil scientists from the Department of Soils and Crops. This reorganization will assure interaction among the physical scientists studying environmental problems and construction of the Natural Resources building will alleviate the current intolerable situation of having faculty widely separated from their colleagues and laboratories. IR-4 pesticide clearance unit will move into space in McLean Lab vacated by Environmental Science.

Natural Resources. A Department of Natural Resources will be established by combining the wildlife and forestry section of the current Department of Horticulture and Forestry with the present Department of Environmental Resources. These changes will remove components from the Department of Horticulture which at present have no association with the traditional horticulture program, and will consolidate faculty with common interests in the study of natural resources. This consolidation will be made possible by construction of the Natural Resources building.

Horticulture and Crop Sciences. Crops faculty from the former Department of Soils and Crops will be merged administratively with plant scientists from the former Department of Horticulture and Forestry.

Physical merger will occur upon completion of a new plant/life sciences building. In keeping with external reviews, emphasis will be placed on establishing an expanded turf research and instructional program, and strengthening the program in intensive production agriculture. A department chair will be recruited to provide the strong leadership needed to lead this restructured department. We will pursue the possibility of closing the soils lab and contracting the work to an external soil testing facility.

Plant Bioscience. Establishment of a Department of Plant Bioscience (A more appropriate name indicative of the department's programs should be considered) is a top priority for strengthening the Cook/NJAES basic research program in plant science and positioning it to interact effectively with the new Center for Agricultural Molecular Biology (CAMB). The purpose of this department is to provide leadership in the basic plant sciences and to form a bridge between CAMB and basic and applied research in related departments. The success of this important initiative depends on quickly freeing up space to incubate this new department, and construction of a major plant/life sciences building to house Plant Bioscience, Horticulture and Crop Sciences, Plant Pathology, and Entomolgy.

Initially, the Plant Bioscience Department will consist of a new chair, four new lines, and the acquisition of the five plant physiologists from Applied Microbiology and Plant Physiology and from the existing Crops faculty. A high priority will be placed on making additional lines available to this new department through attrition and other means. It is anticipated that many of the new lines associated with CAMB will be tenured in this department. Careful consideration must be given to defining and strengthening the presence of biochemistry, toxicology and microbiology at Cook/NJAES as they relate to reorganization of similar programs on the Busch

Campus and to the development of the Department of Plant Bioscience.

Biochemistry and Microbiology. The relocation of the soil scientists from Lipman Hall to the new Natural Resources building and the movement of plant physiologists from Lipman Hall to a new plant/life sciences building, will free up adequate space for the Department of Biochemistry and Microbiology in Lipman Hall and possible espansion of the microbiology program; renovations to Lipman Hall will accomodate this objective. Initiating a new program of Applied Genetics will require renovation of the old Plant Physiology building.

Marine Sciences. In conjunction with the new Center for Marine and Coastal Sciences, a Department of Marine Sciences will be established and housed in a new Marine Sciences Building. Ten new faculty lines will be required and a chair will be recruited.

CAPITAL IMPROVEMENTS AND EQUIPMENT

In the next five-year planning horizon, $127 million in capital improvement and equipment costs is projected to achieve Vision 21 objectives.

To date, the station has been led to believe that about 35 percent of the total is or will be available from university sources. Efforts must be exerted to better assure the commitment and timely allocation of the remaining funds needed, primarily from state and federal sources.

VISION21: 5-YEAR CAPITAL DEVELOPMENT PROGRAM

NEW BUILDINGS	GROSS SQ. FT.	PROJECT START COMPLETE DATES
o Center for Advanced Food Technology	32,000	1987/1989
o Natural Resources	45,000	1987/1989
New Department of Natural Resources		
New Department of Environmental and Soil Sciences		
Center for Agricultural Molecular Biology (Temporary)		
o Greenhouses and Headhouses		1987/1991
Glass	53,000	
Headhouses	7,000	
o Small Animal Care	11,900	1988/1990
o Plant/Life Sciences I & II	149,000	1988/1990
New Department of Plant Bioscience		
New Department of Horticulture and Crop Sciences		
Department of Plant Pathology		
Department of Entomology		
o Center for Agricultural Molecular Biology	90,000	1989/1991
o Center for Marine and Coastal Sciences	54,200	1990/1992
RENOVATIONS		
o Thompson Hall/Nutrition		1987/1987
o Lipman Hall/Biochemistry and Microbiology	40,000	1990/1992

OPERATIONS

Substantial increases in the annual NJAES operating budget also are reqired and must include not only new program needs but also restoration of the budget base eroded by a number of years of not keeping pace with inflationary trends. Initial estimates indicate the need to add and support about sixty new faculty lines to conduct expanded research and extension programs outlined in Vision 21, within the five-year planning horizon. Moreover, additional support will be required to operate the expanded programs at on-campus and off-campus facilities.

EPILOGUE

Although the resources required to fulfill this master plan are substantial, the investment is not prohibitive. Regrettably, in the modern era of its long and distinguished history, there has not been a state appropriation for capital construction for the NJAES. Certainly, this is the time to mount a campaign for such funding to be supported by the food, fiber and environmental communities and industries of the state. This effort, together with resources from the Fund for Distinction can readily bring this plan to fruition and with that, Rutgers University to premier land grant status.

Strategic planning is a continuing process. Vision 21 represents a strategy to meet current and foreseeable needs to propel Cook/NJAES forward as we approach the twenty-first century. As conditions change, thrust areas may be modified and education, research, and extension programs will be redirected as warranted. The core of the Vision 21 Plan provides the initial base requirement for Cook/NJAES to achieve and sustain excellence.

Senator CONRAD. Chairman Brown, would you like to proceed with questions?

Mr. BROWN. Well, Dr. Day's testimony opens up an interesting line which I wanted to pursue, with regard to the very successful wheat breeding program that you have there. The European Community, and I presume Britain is reflective of this, has become a wheat exporting community in competition with the United States.

And this raises the problem how do we relate agricultural research to the total problem of what you might call strategic marketing for agricultural commodities? We are going broke raising wheat, and I presume the European Community is going broke raising wheat because we both subsidize it in various ways. And the focus of research is strictly on the improvement of the productivity of the farmer, not what agriculture needs today.

It is an important need, but it is not the sole need. Now I am interested in whether we may not also need, therefore, a research program on economic forecasting or systems approach to global agriculture, or some other way in which we can focus on the profitability of agriculture? Does your experience give you any clues as to how the excellent research programs involving plant productivity can be coupled with equally good programs in global market analysis and other aspects that would relate to the productivity of agriculture?

Dr. DAY. Well, of course, Mr. Brown, the dilemma is that you want to sustain the farming communities and the basis of your productivity. And in the European Economic Community, you do this by subsidizing them and guaranteeing them a price for their produce so they can make a living, and this, in turn, encourages overproduction.

My plant breeding colleagues used to say that the old aircraft hangars that are filled with piles of surplus wheat are a monument to the efficiency of plant breeding, and the difficulty is that we have got the economic facts wrong.

Now the problem that we were facing at the Plant Breeding Institute in the time when resources were being cut was that we did not address the really important problem, which is to forget about wheat breeding. We were dazzled by our success, in a sense, and to concentrate instead on what everyone is screaming for, alternative crops and to give the farmers something else to grow that is not in surplus that is needed, and in which the market forces can play a role.

Mr. BROWN. If I just may interrupt, the alternative form of that is additional uses for same product.

Dr. DAY. That is true. Now one important feature of the PBI breeding program had very unfortunate effects on the demand for North American wheat. Not only is yield high there, because of the extraordinarily favorable growing conditions—the national average yield is about 8 metric tons per hectare, and that compares with 2 metric tons per hectare in the wheat growing lands in North America—with record yields of the order of 14 metric tons.

But the point was that this is generally speaking of rather low protein quality. Now, addressing this need reduced the dependence of British millers on baking grists that were made up of North

American Hard Red wheat from 70 percent down to 30 percent, and it is still falling, simply by attention to quality.

So I think that shows the way that when you really make up your mind, and you focus on an important program, you can do a great deal. Biotechnology enables you to do it still more efficiently.

So what we have to do is to identify what are the appropriate targets, and you are absolutely right, economic analysis is a very important part of that. And do you know that the AFRC, as far as I know, still does not have an economist in its headquarter's staff, which I think is short-sighted.

Mr. **Brown**. Well, I raise this question about the economic analysis because I have felt that the emphasis upon this type of research in our own Department of Agriculture has probably declined over the last few generations in contrast to the research on production agriculture.

And we have to face the reality that we have a global economy in which we have to compete based upon productivity, and our aim in agriculture is to have the most productive agriculture, the most competitive agriculture, but not necessarily to maintain the most farmers farming.

We do not do that for any other industry. We seek productivity and fundamentally the reason for that is that you achieve the most effective and satisfying human society when everybody is engaged in the most productive activity. They do not have to be doing the same thing their fathers did in order to do that.

But that produces a host of complications of a political nature when you have stable agricultural societies as we do in Europe and Japan, for example, with considerable political influence, and in the United States, too, I might say.

If I may go to one other subject, if you will allow me, Mr. Chairman. I think all of you would probably agree—your statements seem to indicate—on the need for substantial increase in funding for competitive grant research. A suggestion of raising this from $42 million, the current level, to $500 million is probably realistic.

That still leaves about a 2 to 1 ratio for formula grant funding. The question is how do we get from here to there? And the problems are very difficult. I want to ask you to think in terms of how we get to there, and to comment on it.

The problem is there is a considerable resistance to these increases both in the Congress and to some degree in the agricultural research community because of the fear that this will result in a reduction in formula funding. Can we adopt a strategy, for example, that would guarantee some growth in formula funding along with the growth you are proposing here, which is a 10-times over multiplication compared to grant funding?

Could we do something innovative like we do for crop support payments in which we say that as long as you produce surpluses, the price support level will go down? We do that with dairy, for example. And say that as far as competitive grant funding is concerned that you get increases as long as the amount of dollars we are spending for support payment continue to go down.

If they do not go down—in other words, you fund competitive grants from the savings you make in the commodities support program. Can we do something like that? I raise it for your comments.

I want you to rise above your role as researchers and think in terms of politicians now.

Dr. **Hullar**. Let me lead off. I guess I am not quite sure I want to rise quite to the level of a politician.

Mr. **Brown**. I can see that.

Dr. **Hullar**. Well, no one could rise to the level of Congressman Brown, first of all. But I think I best leave the politics of this to you. It does seem to me that if we look at the $20 billion that simple arithmetic would say there has got to be some money there.

I make two comments. First, there is a broad view that at least some of the $20 billion that is presently going into agriculture should stay in agriculture, but be redirected. That is a reasonable argument. Where to redirect it, such as to make the producing of crops either more efficient or more profitable, is an appropriate strategic issue.

Second, on the matter of the balance, a number of things can be said. Let me just lead off with a couple. There certainly is a belief, and Dean Hess on our campus at Davis is now documenting it, that there has recently been a very large redirection of the formula funds from research that may have been fashionable and traditional and applied, if you will, 10 or 15 years ago. The redirection of those funds has been into some of the modern research areas.

Dr. Day has said something that bears very directly on this. It is a redirection within the agricultural research community, and it is toward and, indeed, into molecular cellular genetics, developmental biology, the very things that underlie the development of the wheat program at the PBI.

That is one end of that corridor. What we are talking about here in my proposal is the other end of that corridor. It would seem folly to diminish Federal attention to the one end of the corridor while we are increasing it on the other end, partly because one gets out of balance.

It would, in a political sense, in my judgment, diminish the interest of the State in participating. Federal funds, leverage State funds; one works with the other, and does so very effectively.

That is particularly true in smaller States, New Hampshire, Vermont, Maine.

Senator **Conrad**. North Dakota——

Dr. **Hullar**. North Dakota, South Dakota, Montana, Nevada, Wyoming, even Colorado and some of the larger States; many, many places. I think it is in the national interest to be sure that we at least sustain institutions there. Indeed, I would assert we ought to be building them in an effective way.

The most effective way is to sustain the level of funding, Federal funding, maybe even on the condition that the State funding stays. And then supplement that in this balancing approach that I outlined in my testimony with competitive grants because in every one of those States, there are absolutely top-flight researchers that can get competitive grants just as easily as they can at Davis, Berkeley or UCLA or Stanford, or Rockefeller or Harvard. And they are doing it right now.

But we have to provide increased capacity for them to get it. That is why we need to increase this $42 million to a much larger amount. I could keep going but I will just stop at that.

Mr. BROWN. I would appreciate any comments from others on this subject. Yes.

Dr. CHILTON. I would point out I have an industrial perspective on this rather than an university one. When CIBA-GEIGY decided to make a move into biotechnology, it did not fire one plant breeder for every molecular biologist it hired. It added. What you do when there is new scientific opportunity is you enlarge your effort with the bet that it is going to be important later on. It is no guarantee. That is one argument I would like to make.

The second argument I would like to make is when you think about making this research investment, you have to think not only about the cost of doing it, but you have to think about the cost of not doing it. If we do not do that research, somebody else somewhere else will, and we will be licensing it from them. They will be selling all the seeds. Our farmers will be buying from them, and we will pay for it that way.

Dr. HULLAR. In fact, there is no reason to believe that right now other nations are diminishing their efforts. In fact, there is every reason to believe they are increasing them. Professor Sequeira, who is with us today, made a comment, really anecdotal evidence, that he developed in a recent trip. He said they are rapidly intensifying in the country he visited. That is certainly occurring. Look at what the PBI was doing. It is occurring all over the world.

Mr. BROWN. Well, agricultural technologies like other technologies are now spreading all over the world very rapidly.

Dr. HULLAR. That is correct.

Mr. BROWN. That is the reason that the world is now food self-sufficient broadly speaking. We will not be competitive in that environment because we cannot match the economic conditions of labor costs and so forth, or sometimes even climatic conditions.

We have to focus on maintaining a research program that will vastly increase our productivity, the output per labor cost.

Dr. HULLAR. That is right.

Mr. BROWN. And if we understand the importance of doing that as the only way to maintain a viable agriculture, we may be able to get the funding. But there are not enough Members of Congress who understand that today in my opinion.

Dr. MARSHALL. Mr. Chairman.

Senator CONRAD. Yes, Dr. Marshall.

Dr. MARSHALL. I would just add one supporting comment. I agree with the statements, but I think it is important to bear in mind that formula funds, Hatch Act funds, support a different kind of research than competitive research grants.

And it is true that the two ends of the corridor exist, but that corridor is 3,000 miles long. We have land-grant colleges of agriculture that are only at one end of the corridor. And I would urge you, if it is possible in the competitive grant scale-up, to try to bring the vast number of our colleges of agriculture that only operate at one end of the corridor toward the other end of the corridor by what I have called joint proposals.

Try to get the cosigners of the proposal from each end of the corridor, even though they may be 100 miles apart. I would imagine Rutgers' campus is no different than any other campus. One end of the campus might as well be in another State as within walking distance.

I mean they do not necessarily collaborate. That collaboration has to be encouraged, if not forced. So I think that one of the real advantages of competitive grants, if you can use money to force the researchers to come together, and that they respond to very quickly.

Dr. HULLAR. If I could just pick up on that notion. I think the principle that Dr. Marshall laid down is a very good one. I think we saw it first in the agricultural research community with the McKnight Foundation proposals. It had a salutary—in fact, it was a cannon-shot across the bow. It riveted people's attention to collaboration with disciplinary colleagues outside one's own specific areas.

It was a multidisciplinary approach. Strong proposals came out of that. Some of them became part of the National Science Foundation's Science Center's effort. That would be one approach.

Another approach would be if we look at, again, the corridor analogy, there is an application side and a discovery side. We have all spoken to that. That might be another criterion. Dr. Marshall gave a specific example for that. But that could be built in.

There could be some incentive mechanisms for the direct collaboration with industry such as there was in the Research Applied to the Nation's Needs (RANN) program, and such as there is with some of the engineering science center programs.

I would think that if we really are interested in institution building, we would identify the institutions that should be built. We have mentioned some of the States that really are having a hard go for their own State economic reasons.

We can think somewhat regionally there. North and South Dakota relate to Minnesota and Wisconsin, for example. We could possibly work some things out there. I think we could really be quite inventive about all that.

I would say also there is another category of issues that is worthwhile focusing on. And that is an issue that I characterize with an example. It is the loose soils of the Pacific Northwest. A unique collaborative effort has been created to address those: ARS funds and scientists, CSRS funds through the special grants program, and other entities. Collaboratively they are working on that. It is a special grants program focused on a big problem that is multistate in one part of the country.

Now it could well be that one way of again ensuring the continuity and the collaboration of many people is to identify really key problems like that around the country. One that comes immediately to my mind is water quality in various parts of the country. The problem of water quality in Iowa is with nitrates from fertilizer.

The problem of water quality in some other places is possibly with pesticides getting into the ground water. But these tend to be regional problems. They might tend to have regional solutions based on local physiographic, climatic conditions.

And again, there is a category there. It is not the basic research side so much as it is between basic research and the applied. So there is an adaptive research, applied research, and extension, an overt technology transfer component. It is another category.

I do not think any of us would believe that this class should come out of a competitive research grants program of the kind I mentioned. But it is another category of things, again, to create the fabric of agricultural research, technology development, and application, to create that fabric even stronger.

Mr. **Brown**. Why do you not go ahead, Senator.

Senator **Conrad**. Help me with a problem I am having in understanding your proposal, Dr. Hullar. You are proposing a $500 million increase for competitive grants for basic research. In the hearings that we have held over the last year in the subcommittee on the Senate side, we have heard repeatedly that there is a great need for additional funds to commercialize reseach product ideas. The underlying basis for that set of hearings was the USDA New Farm and Forest Products Task Force .

Perhaps you are familiar with that task forces' recommendation. The private sector and public sector together did a lengthy analysis, and they came back and told us, look, where we are missing the boat is in commercializing the basic research that has already been done. They looked over American agriculture, and looked over what is happening in the basic research, applied research, and commercialization sectors. Their conclusion was that we have an enormous opportunity here in commercializing research that has already been done.

The Japanese are excellent at doing this, forming public-private partnerships in order to commercialize new products. This proposal that you have made seems to me greatly at odds in terms of priorities with what the task force recommended, and frankly, with much of what we have heard in previous hearings. What is your reaction to that difference?

Dr. **Hullar**. I do not know about that other report. If some of my colleagues do, maybe they should speak to it. And I am not a molecular geneticist as Dr. Chilton is. But one of the things that I have kept hearing as an experiment station director and as chancellor is that we do not know enough about the metabolism of plants so that we know how to create added value to our products, such as increasing the protein content, or added value to oil-bearing crops such as those that would be grown as alternative crops in the Southwest and possibly elsewhere.

We certainly do not know enough about how to create herbicide resistance because the metabolic pathways there are not known, and Dr. Chilton referred to her own path-breaking approaches of getting vectors to work in plants. I do not know how many vectors we now have, but it is not very many. So there is just a lot of the fundamental biology that is not known before we can sort of clean up, if you will, some of the sledgehammer approaches that we have in agriculture. Sledgehammer meaning chemical pesticides that go over a field and do things.

Senator **Conrad**. Let me try to refocus this because it is, to me, one of the high priority, threshold questions we have got to address. We are idling in this country, I think, somewhere in the neighborhood of 80 million acres through set-asides and the Conservation Reserve Program. That obviously has all kinds of consequences out in rural America, consequences to farmers who must idle their acres and consequences to Main Street.

If you would come to my State, you would see a State that is in serious economic trouble. It is not just the drought. It is much more than that. It is the idling of productive acres. It is not having a sufficiently diversified base. It is what Dr. Day talked about in terms of losing market share for the Hard Red Spring wheats and not having replacements.

Again, I would say to you that the task force that USDA put together, which was private sector-public sector, concluded that the Federal Government ought to establish a billion dollar initiative, to commercialize research that has already been done for new products and new uses.

And now we have this hearing, and we hear you ought to add $500 million for additional competitive grant projects.

Dr. HULLAR. To create new knowledge to make the problem worse.

Senator CONRAD. Yes, exactly. You understand what I am saying. I am hearing two very contradictory messages, which if I total them, recommend a $1.5 billion increase, which is about 100 percent increase, in funding. Yet I tell you we are going to be faced, I think it would be fair to say, with an all-out war 3 months from now on the Federal budget. Whoever the new President is, he is going to inherit a budget mess of colossal proportion, with a tripled debt, and many other problems.

If you were sitting in my seat and had these kinds of contradictory evidence and funding requests put before you, how would you harmonize them?

Senator BOND. May I?

Senator CONRAD. Yes, Senator Bond.

STATEMENT OF HON. CHRISTOPHER S. "KIT" BOND, A U.S. SENATOR FROM MISSOURI

Senator BOND. Mr. Chairman, I apologize for interrupting. I have about three other meetings going on at this moment. I wanted to come by simply to commend you and Congressman Brown for holding this hearing. I think getting these things out on the table now is extremely important. It is an area that we ought to be spending some time on.

I would like to submit a brief statement for the record.

Senator CONRAD. Without objection.

Senator BOND. Again, my sincere thanks to you both. Even though I do not serve on this subcommittee, I look forward to working with you, and I look forward to reading the record of this hearing so I will be up to speed on what these witnesses have provided. Again, my apologies for interrupting—but it is important enough that I wanted to come by.

Senator CONRAD. Let me commend Senator Bond because no one has been more active or, I think, offered a more constructive approach to these issues than Senator Bond. He has been involved in every initiative that we have had in trying to address these concerns responsibly, and I very much appreciate his interest and his involvement.

Senator BOND. Thank you, Mr. Chairman. Congressman, thank you.

[The prepared statement of Senator Bond can be found on page 3.]

Senator CONRAD. Dr. Marshall.

Dr. MARSHALL. If you would look on research as a continuum from the very fundamental to the applied, Mary-Dell spoke about the fundamental sciences, and we are talking about the corridor and so forth. It cannot be broken out into discrete pieces like basic and then it goes applied, and bingo, commercialization. Companies are not going to undertake certain kinds of research.

What we have with the advent of cellular biology and its discoveries and its impact on agriculture is a movement more fundamental. We have, in general, seen over the past, probably 30 years, the colleges of agriculture and the State experiment stations becoming more focused to applied.

Now the gap is growing. We have the private sector which is moving more to short-term gains and profitability. So we have these gaps. It is bimodal. And that is reality. There are some colleges of agriculture, the State ag experiment stations, that are going to stay fixed there.

And if it is the wisdom of Congress to keep those experiment stations going, there is formula funding for that. You can use competitive research grants to get this thing moving deeper or further fundamental, if you want, or you can get it to move further this way.

I would suggest that what you attempt to do is use competitive research grants to close these gaps. There is an awful lot of stuff, true, as the USDA task force reported, that is ready to be commercialized. But it is going to take years to commercialize it because it has to go through this continuum of product development, commercialization, scale up, and the whole business before it gets out there. And that costs an enormous amount of money.

But I think the value of the competitive grants is that you can say we want a certain amount of this money to be used to do that, to move it from here to here or to move it from here into the private sector. Mary-Dell also spoke about intellectual property, and I think that is an exciting concept.

There again she is talking about from this point forward, commercialization. I think competitive research grants can be used to move the fundamental closer to the applied.

Senator CONRAD. If I hear you right, you are saying that you would amend Dr. Hullar's recommendation and say you ought to be dealing on both ends of the continuum with additional competitive grants?

Dr. MARSHALL. I would not just take and throw more cash into the existing kitty. I would say what we want that money to do is this, and then we could have many days of meetings about what this is. But I think for this discussion we are talking about moving stuff through.

But the next step is not from fundamental to commercialization. The next step is to get the problem in the hands of the applied researchers, the economists, the people that can tinker with this, and find out if there is a market, and then move into commercialization.

And the reason that all this stuff is sitting there is not because the private sector is unaware of it. It is because it is still too fundamental for them to risk the dollars to commercialize it.

Senator CONRAD. We understand that. What we have repeatedly heard over the series of hearings that we had last year was, look, what is happening to us as a country is that our competitors are doing a much better job of forming these public-private partnerships to commercialize new products. The Japanese, for example, are perhaps the best at it.

The Japanese identify that basic research that has already been done, many times by other people, and they say we are going to run with this idea. We are going to commercialize it, take it to the market. And they do, and we in the United States wake up to find that they have taken basic research done in our universities, and lo and behold, have gotten the commercial product on the market. Dr. Chilton.

Dr. CHILTON. If that is the challenge, and I agree that it is, it is not the challenge that really makes an impact on what we are talking about. I think we are talking about something very different. That is a different problem. It is a political problem. Japan in many ways is like one big company. They do not have the antitrust legislation that we have in the United States.

We would not be allowed to operate like that. Our company would be considered immoral, not to say illegal, if it were as intimate with other companies and with the government as goes on routinely in Japan. So if that is making unfair competition, we have to deal with that on its own basis and merits and not hang that albatross around the neck of research. That is not researchers' fault. It is not a research problem.

Senator CONRAD. No, we are not suggesting it is the researchers' fault. But if you sit in our position, you see that we have a limited pot here to deal with. We have had our administrative agency, USDA, come back and tell us, look, if you are looking for the biggest gap that exists in the research continuum, here it is.

It is at the commercialization end of the research process. Yet what I am hearing here today is that we need to dramatically increase research funding for the basic research end of the continuum. That is at great variance with what this task force came back and told us.

Dr. HULLAR. I think it would be useful. I do not know this task force report. I think it would be useful, if this is a concern, that some of us be asked to look at this, and ask the question is there really a problem in transferring the knowledge, and if there is, whose responsibility is it to solve it? I think we have two themes that have presently been presented at the table.

One is that it might be the government's problem to solve that. That means an intermixing of the government with the profit structure of the private sector.

Senator CONRAD. That is the conclusion that the task force came to, by the way.

Dr. HULLAR. That is not something we do in this country, at least not routinely. If we wish to do that, that ought to be an up-front discussion, and there are many players in that. I am not sure that the government would want that because I think one of the requirements is that a lot of stuff in that has to be really public and therefore really available to lots of folks.

That is the Japanese model, though, as Dr. Chilton just said. But I think it would be useful to know just what the problem is to analyze it. I certainly do not feel equipped to do it. Maybe that is something that the Board of Agriculture, in some fashion, could take a look at. It might be something that we could develop after this session.

I just have to return to the view that I expressed, though, that we simply do not understand enough about plant and animal metabolism, just to pick those areas, to really understand how to create internal mechanisms, internal to the plant or animal where they control their own pests in an agricultural production setting.

We have to keep applying these external forces, and that creates lots of problems. It costs money. It creates environmental problems and food safety problems, and it takes a lot of management time, which is probably hurting a lot of farmers, as well.

Senator CONRAD. One of the things, Dr. Chilton, that you raised that I wanted to follow up on was the biotechnology and the need for funding in that area. Do you have any idea what the relative funding levels are in our country versus our major competitors? Do you have any sense of what we are doing versus what they're doing in terms of commitment in this area?

Dr. CHILTON. I do not. Does Peter Day have more insight? How about compared to the UK?

Dr. DAY. Well, the difficulty, Mr. Chairman, is that it is comparing apples and oranges. I can tell you, for example, that the annual research budget of the Agricultural and Food Research Council is about $100 million a year, which is very small in comparison with the United States.

Now how you factor that to make it a valid comparison, and do you do it by dividing by the population. Perhaps if you did that, you would get some meaningful results. Obviously, you would have to do that.

But can I change the subject because it seems to me we are skirting around an issue that Congressman Brown raised, and that is the $500 million that we are saying is very important to remain competitive and to continue generating material that the commercial sector and the country needs.

Where is it going to come from? I imagine that your critics are suggesting that if there is such a disparity in formula funding versus this amount, how are you going to address this shift of the balance without an increase in the total size of the pot? Is there a way in which you can move some of the money from one area to the other? We are not addressing this question.

It is a difficult one because it involves grasping some very unpleasant nettles, which we have been through in Britain, but do you see that as a direction that we are going to have to take?

Senator CONRAD. You have put your finger on it. That is a very nettlesome set of issues. What Dr. Hullar indicated was that we would leave formula funding as is, and the $500 million would be new money. Frankly, I think that would be a pretty hard-sell proposal around here. I would be interested in Congressman Brown's reaction.

Mr. Brown. Well, that is why we have to carefully go through the strategy for doing it. We will not get it overnight. We will not get it next year. We would perhaps be able to get it over a 5-year period, if we very carefully worked out a strategy to do it.

The administration has recommended at least 100 percent more than the Congress has voted. The first step ought to be to accept the administration's recommendation. That is a doubling of the competitive grant program right there, and hope the next administration, regardless of party, will be similarly enlightened and, say, permit a 50-percent increase per year for 5 years or something like that. That would be one strategy.

You will not get that in a vacuum. The program, the competitive grant research program, will have to be tied to a research agenda which tracks the political support of the various elements here. It will have to include what the Senator has indicated about making use of already existing research.

That means cooperative programs with industry, probably to commercialize. The government cannot commercialize. Industry has to do that. We need to focus some on the type of research that the Senate has already supported several times by passing legislation which is alternative uses of existing crops.

We do need a major component of research on that, and it can be, it should be competitive, and it could be focused to some degree on biotechnology, because that is going to be the mechanism that will help us to develop that.

But based upon hearings of this sort and others, we are going to have to carefully craft, we will say, a 5-year program, just like the academy does sometimes, and develop a step by step approach to achieving the goals that we set forth.

Senator Conrad. Dr. Chilton.

Dr. Chilton. Could I try to address your questions in another way?

Senator Conrad. Yes.

Dr. Chilton. I submit that those are the wrong questions, and that is why you are not getting the answer. The question is not how do we justify doing research. If you go into a research program saying I have to see how this is going to pay me back, then you will never do any research.

Senator Conrad. I do not think anybody has asked that question. I do not think there is any argument about the need for basic research.

Dr. Chilton. OK. If you begin to hack away at the roots of the research structure by cessation at the fundamental level, then the tree will not die very fast, but it will die. I can guarantee it.

Senator Conrad. Again, I do not think anybody is proposing that.

Dr. Chilton. All right. Now the second rider that I would like to put on that is the developments in biotechnology have changed everything in biology over the last, let us say 10 years, give or take a few. Biology has changed in a fundamental way. The things that you can do to organisms have changed in a fundamental way.

My company is a very conservative company. It was the last company to move into biotechnology, reluctantly and very cautiously. It moved into biotechnology because it became convinced that agriculture, which is a sector in which my company wants to operate and serve, is going to be changed radically by this new technology.

If that philosophy is correct, my company reasoned, and I submit that the United States needs to reason, we cannot afford not to be there with all four feet. Now what you are hearing from the testimony this morning is we are not there with all four feet. We are there with a little toe maybe. We are not doing nearly enough.

There are bright young people who are not going into this field because they cannot mount a decent-sized research program. In the health related area, times are much rosier and brighter. People do not go into plant work because of lack of funding.

An academic realizes that his future livelihood, his whole career, is dependent on how much research grant support he can get. So what you are hearing from us is never mind about what the consequences are. What you have to do is this: find out a way to do it. You have to increase the support at the fundamental level, and that means competitive research grants. It means fold-increases, not incremental 10 percent increases, but fold increases from where we are.

Senator CONRAD. The problem that I am trying to focus on is our research priorities. That is what we must deal with. What we have before us is a recommendation that if we are able to increase research funding, that we ought to apply it to the commercialization end of the research spectrum. That that is where our biggest gap is.

What I hear you saying is that the biggest gap exists in basic research. They are two conflicting signals.

Dr. HULLAR. You know I do not want to speak for all of my colleagues on this. I am quite convinced that the four of us today cannot address this to the detail, even to your specific questions, Senator Conrad, or to, let us say, the phasing in program development questions of Congressman Brown.

But I am sensing that there is so much support for the breadth of the agricultural, not just research community, but the agricultural leadership community, at least at the university level, that I do not doubt for an instant that we cannot, in the period of the next few weeks or couple of months, put our heads together, possibly with some guidance from this committee, as to some parameters, and determine what some more specific elements of this program might be.

We have a lot of ideas. I spun out a few of those earlier. But I think we could do that. And when I say the agricultural, the university agricultural leadership community, I do mean those deans. They voted unanimously to support this program. They know we must do more. They are looking to a few of us who are involved in this to provide to them some leadership, and we are prepared to do that.

And the whole university ag research community, which is in many cases quite closely connected with industry, is equally supportive. So I think that could be done. It might be useful for your staffs, some of our staffs, to have some conversation about what some of these parameters, constraints and sideboards might be, and we could bring something forth.

Senator **Conrad**. I tell you what I think would be very productive for all of us. All of the elements of the community, including industry, academia, and the government, must get together and set out what are our Federal research priorities. We need to identify the gaps and identify and weigh the alternatives as to where we should make the major push as our homework before the 1990 farm bill. Perhaps we would conclude that competitive grants should be the focus of our research push as Dr. Marshall recommends.

You have to focus on both ends of the research spectrum here. This is, by the way, the task force report that I was referring to. But I think if you have a chance to look through this report, you would better understand the kinds of conflicting recommendations that are being presented to us.

Congressman Brown and I have a responsibility to try to come back with a coherent message to our colleagues. If we do not have that, we will have absolutely no way of being successful.

Dr. **Hullar**. You have nothing; right.

Senator **Conrad**. What we very much need is to try to put together what we are hearing from various communities and develop a coherent message.

Dr. **Marshall**. Could I try to address that conflict and why perhaps it exists? It depends on who you talk to. If you speak to State ag experiment station directors or deans of colleges of agriculture of approximately 30 of our 57 institutions, they do not have the wherewithal to take the fundamental knowledge and make it commercializable.

They cannot take it to that next step. About 15 of our colleges of agriculture State ag experiment stations can do that. If you talk to those people, they will say they need more money on the fundamental end because they are having trouble making things work in the field. They do not understand the science, and that is the same for private industry.

We see things in the field that are not working. They work in the laboratory. The theory is there. The fundamental studies say it ought to work, but it does not work. So we say you have to go back to the labs. So that is what you will get from those 15 deans or experiment station directors.

If you speak to the other 30, they will say not in so many words, but they will say we are unable to do that, and so we want the private sector to take that fundamental knowledge and commercialize it because they have the wherewithal, the Monsanto's, the CIBA-GEIGY's, et cetera, and so forth.

So one of the things that I have found over the last 5 years which was a surprise to me is that the land-grant college of agriculture/State ag experiment station is not a monolithic organization. There are at least two distinct groups of schools there. And the one group, the vast majority, some 30 of the 57, rely heavily on Hatch Act money to keep themselves going. The other 15 can get money from anywhere. They are strong schools.

So you will also get two different answers from those groups.

Senator **Conrad**. Absolutely.

Dr. **Marshall**. And I think if you want to get a prioritization, if you put those two groups together, you will probably have an explosion rather than a prioritization. I mean they have two quite different sets of problems, and I think they almost have to be addressed that way.

You have to say, OK, this is what we have to do with this part of the system, and this is what we need to do with this part of the system. And if our national priorities are to do this, maybe some of it can be done here and some of it can be done there.

But we have for so long just looked upon this thing as a monolith and expected it to speak with one tongue, and then we get confused when we do not hear one tongue.

Mr. BROWN. Well, I would comment that I have observed from long experience this diversity of views in the community. I think it can be addressed, and I want to devise a strategy that will address it. In looking again at your statement, Dr. Hullar, you have got two five point items here. One is the challenges and opportunities.

And you know, looking at it again, this does not contradict the kind of thing that is contained in this "New Farm and Forest Products Task Force Report." [1]

Dr. HULLAR. No. It is completely consistent with that.

Mr. BROWN. You have got a perfectly consistent program there.

Dr. HULLAR. Perfectly consistent.

Mr. BROWN. And then your five point proposal on the competitive grant research, again, is quite compatible with the challenges and opportunities here. But the problem is that we talk at different levels sometimes. To secure political support for something you have to talk at one level. To achieve a coherent, encompassing program, you have to talk at another level of complexity or sophistication or whatever you want, and sometimes the problem of matching the two in order to get the psychological effect that you need.

Dr. HULLAR. I do not want us to leave Dr. Marshall's point if I may respectfully demur. There is a spectrum of institutions. The ends have some of the characteristics of Dr. Marshall, but I believe it is a spectrum, not two groups.

There is the Council of Administrative Heads of Agriculture, the deans. They are comprised of the big's and the little's, the strong's and the weak's for basic or applied. And there was unanimous support for this, and they knew what they were doing.

They knew what they were doing because 10 years ago, as Bill knows very well, and as all of us know, they were vigorously opposed—I should not say all of them, but a number of them were vigorously opposed to any increase in competitive grants.

As a number of us here at the table know, and some of us worked on it even, 5 years ago we brought forth a program for a proposal for $70 million increase in competitive research grants within the USDA structure for biotechnology. That was accepted at the level of $28 million.

That was the first major increase since the program was started in 1977. There was some reluctance on the part of some of those heads of agriculture and some others in that university community. I sense no such reluctance at this time. That does not mean that we are not going to have to work together, both within that sector and with the industrial sector of the commodity organizations and the like, to fashion a program that does indeed meet in maybe some rather explicit ways some of the specific things in these documents.

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[1] This report is retained in the subcommittee's file.

But that is already part of our strategy. The strategy document, as was prepared, states we need a coalition, including national commodity organizations. There is the dairy and there are the four plant ones, and they are going to be very much part of this. And if we cannot sell this idea to them, there is no reason for us coming back to this table.

But we have set as one of our number one agendas to, in fact, work with them in a close and collaborative basis.

Senator CONRAD. That is terrific news. I am convinced from listening to the various communities that we have listened to during this process that there is a way to get together. I am also convinced from watching the process here that if we do not have a broad coalition, then we do not have any chance to succeed.

Dr. HULLAR. Right.

Senator CONRAD. But if we would agree to an overall program—obviously there can be some differences—but if we could agree to a broad strategy, as Congressman Brown has described, then I think we would have a real shot at convincing our colleagues of the need for additional funding. But if we get down the road and we have conflicting messages from various parts of the community, such as the commodity groups or industry groups, for example, then we do not have a chance.

Dr. HULLAR. Right.

Senator CONRAD. If we can propose an increased funding initiative that we are all in agreement on, including the overall outlines and the priorities, then we have a chance of carrying the day around here.

Dr. HULLAR. Here is something else that might usefully be thought about as we do this. And that is being more overt about linking the various parts of this corridor together. Dr. Marshall was talking about gaps, and he mentioned two big ones, and they are big. And I think that is a very good description. I have not heard that put quite that way and quite that well before.

We have to worry about those gaps. He talked about the gap between the development of the applied research and the basic technology. That is clearly there, and frankly it has gone that way very fast. And we have to bring that together.

And the gap between the developing of the technologies and the application is also separating because industry is going off and doing its thing, and universities possibly are stuck in some old methods that do not work. And I think there are some possibilities there for some innovation.

And I think that is one of the things that Dr. Marshall was referring to, and there might be some incentives to do that, that can be created through this. I keep thinking of the extension system, but that is not the only technology transfer mechanism. There are others as well.

Mr. BROWN. I have just been reflecting on a point which I would like to mention. Those of us who work with the research programs of the Federal Government become impressed with the breadth and the complexity and the time involved in making scientific breakthroughs and supporting a sound fundamental research structure in this country.

We sometimes overlook, or neglect, or are completely ignorant of the equal complexity of the process by which research or knowledge is transformed into socially usable, useful products, the commercialization process it is sometimes called.

And I would cite an example that I have been involved in for a number of years involving the commercialization of that important plant guayule, the native rubber plant of the Southwest, which we have been working on for 50 years. It was originally worked on in the late 1930's.

We have made a lot of progress in fundamental research and developing improved strains, understanding how to cultivate it and so forth. There has been some industrial interest in commercializing it, and it has gone up and down, and we sit back and wonder, well, why do we not just commercialize it? It is high quality rubber, and it is important to the national security.

And then you look at it, and you find that whether it is profitable to do so depends upon the cost of oil or the cost of natural rubber imported from Malaysia or wherever, and various other factors, and these tend to fluctuate.

And no commercial company will make large investments in an uncertain future on something like this. And they should not be expected to. The Japanese survive or meet this problem sometimes by a commitment to fund a program that they think has long-range value for long periods of time when it is not profitable. They will put money into a losing operation for 10 or 15 years, knowing that they will ultimately capture a good market, and it will be vitally important.

We do not do that yet. I am citing this as a need for us to rethink how we relate ourselves to the connections between research and commercialization, and the need for new mechanisms and new thinking to really facilitate this commercialization process.

And I think that has to be a part of our package here, not only in agriculture, but we are rethinking this in other areas of technology. There are some provisions in the trade bill that relate to new technologies that reflect this kind of thinking.

And it is going to have to become more widespread. That was a free interjection, Senator.

Senator CONRAD. I liked it very much. One of the other things we wanted to address was research methodology. One of the things that has been talked a lot about is the interdisciplinary approach. We have heard a number of you speak about it this morning. One of the things that has been brought to our attention repeatedly is the systems method where we have broad interdisciplinary participation on some of these research projects.

I would be interested in what emphasis you think we should place on encouraging that kind of research? That is, when we put together an initiative, ought there to be requirements that there be a systems approach used in the research projects selected for funding? What kind of value does that have from your perspective, or does that have a way of diverting people's attention?

Dr. Chilton.

Dr. CHILTON. I think that in a time when a new technology has come along at the fundamental level that can impact on applied science and development, it really is all the more important to specify some funds for the area of interdisciplinary collaborative research.

What is needed in fundamental plant biology today is to have the molecular biologist working hand in hand with the plant physiologist, the cell biologist, the geneticist, and eventually a plant breeder.

One of the crying needs in education today is people who have at least a speaking knowledge of all these different disciplines and expertise in one. Traditional plant breeders were not trained at all in any of this fundamental stuff, or it was all invented since they went to school.

So there certainly is a need for training of an interdisciplinary nature. There is also need for the research that will come out of such a training program. The McKnight Foundation has dedicated a large sum of money—I cannot remember what it is to tell you today—but a great chunk of their resources in plant biology to an interdisciplinary training program at five to six universities across the country.

Every 3 years they open the competition again. It is open right now. We are in the semifinals of it, and it is impressive to see. I have been through two cycles of this already. This is the third cycle. It is impressive to see how much better the quality of proposals of interdisciplinary proposals has been in 1988 than what we saw 3 years and 6 years ago. So things are coming along.

It should, I hope, impress you that the McKnight Foundation in its benevolence saw that a national need lay in this area of supporting that kind of research into plant biology. If they saw it, I hope that you can see it.

Their program is scheduled to finish in 3 more years. This is the third and last cycle that is foreseen. I would love to envisage that the Federal Government will take up that torch and carry on with a similar program in the future. I think it has been wonderful.

Senator CONRAD. The McKnight Foundation's work has really drawn attention and it seems to have been very productive. We hear that it is bringing people together that were not coming together before, and that some pretty impressive things happen when those people actually talk to each other.

Dr. CHILTON. Yes.

Senator CONRAD. Then we ought to encourage interdisciplinary research through our efforts. My question would be what is the best mechanism for that? What has the McKnight Foundation, for example, learned about the best formula for encouraging this type of approach?

Dr. CHILTON. You simply set the rules for a segment of your funds. You set up a program to fund interdisciplinary programs from one university campus, and leave it to the investigators. They will come up with a program.

Dr. HULLAR. I could not agree more. And it is not just in the areas of molecular and cellular biology, biochemistry, physiology, and pathology. That is one broad category, crucially important, but it is other areas, the engineering sciences, material science, robotics, sensing devices, microprocessors, which are also in here, because that relates to field conditions.

We can just imagine some farm equipment manager taking all of these and creating brandnew methods of delivering fertilizers or pesticides or whatever, based on specific conditions in the field as the implements go over the field.

That requires lots of people working together, too. I would give another example. Long Island is a big sand pile in the ocean, as we all know. And there is an awful lot of people on Long Island. There is also a lot of agriculture. Pesticides go through that sand pile into the water. People take that water out and they drink it. That is called Aldicarb and potato farming.

That required a systems approach to solve. We did this, or at least began it when I was in New York. It required people who knew about potatoes, who knew about soil, who knew about pesticides, who knew about water, and who knew about economics. It is a very simple solution. It is called crop rotation. We have done it for a long time. But, we had to have the systems analysis to persuade the farmers that they could still make money if they rotated crops rather than just monoculture potatoes year in and year out and using aldicarb.

It also saved farming on Long Island. So that is a little example, and it occurs across the country. It is going to occur in the soils of Iowa using a systems approach to nitrogen fertilizer levels, crops, water, to keep the nitrate levels down in water in the State of Iowa.

Senator CONRAD. Good point.

Dr. MARSHALL. And I think this is a real strength of the colleges of agriculture that you do not find in the colleges of arts and sciences, the real strength. And that is why I would go back and urge for the fourth time to try to get competitive grants to force the fundamental scientists together with the applied agricultural researcher because the applied agricultural researcher is the only person on campus, I think, that really understands what we are talking about, a systems approach to a problem, because they problem-solve all the time. But you do not have that in the other colleges.

Senator CONRAD. All right.

Dr. CHILTON. I remind you that as Lewis Carroll said, what we tell you three times is true. [Laughter.]

Senator CONRAD. Right. Well, I want to thank all of the witnesses for being here. I also want to thank very much my colleague from the House side, Chairman Brown, for participating. We intend to carry forward with this effort. I want to especially commend Chairman Brown for his initiative in this area.

He has the benefit of a great deal of experience in trying to put together the coalitions that are necessary to move something through Congress. We are very eager to redirect resources where that is appropriate, and add resources where that is appropriate to make sure that we are doing what needs to be done for American agriculture, and for the larger American economy.

Chairman Brown, any final statement?

Mr. BROWN. Well, I would just like to say that I appreciate the chance to collaborate with you in important hearings which bring the caliber of witnesses that we have had here this morning together to help us. I have no magic formula for getting good legislation, but I will observe that it is apparently increasingly important that we have better direct communication between key people in the House and Senate who are interested in these common problems.

And your initiative in arranging these hearings will stimulate that kind of a process.

Senator CONRAD. We very much appreciate your participation. I am going to insert in the record the prepared statement of Senator Domenici and a detailed paper on the task force concept, "A Positive Approach to the American Farm Problem." I will also insert the statement of Hon. Pat Roberts into this hearing record.

[The prepared statement of Senator Domenici and attached paper, "A Positive Approach to the American Farm Problem," by Gerald W. Thomas, follow:]

STATEMENT BY U.S. SENATOR PETE V. DOMENICI

ON AGRICULTURAL RESEARCH

BEFORE THE SENATE SUBCOMMITTEE ON
AGRICULTURAL RESEARCH, AND GENERAL LEGISLATION

SEPTEMBER 29, 1988

MR. CHAIRMAN, I WANT TO THANK YOU AND THE RANKING MEMBER, SENATOR WILSON, FOR ALLOWING ME TO SHARE MY THOUGHTS ON AGRICULTURE RESEARCH WITH YOUR SUBCOMMITTEE TODAY.

FIRST, THE IMPORTANCE AND SUCCESS OF AGRICULTURAL RESEARCH IN OUR COUNTRY'S DEVELOPMENT CANNOT BE OVERSTATED. AMERICA LITERALLY COULD NOT HAVE BECOME THE GREAT ECONOMIC POWER IT IS TODAY WITHOUT A PROGRESSIVE AGRICULTURE INDUSTRY. AND AGRICULTURE RESEARCH HAD A GREAT DEAL TO DO WITH CREATING THE WORLD'S MOST PRODUCTIVE INDUSTRY -- AMERICAN AGRICULTURE.

OUR AGRICULTURAL RESEARCH SYSTEM IS NOT PERFECT, HOWEVER. CHANGES AND FINE TUNING ARE NEEDED. A CRITICAL LOOK AT THE SYSTEM REVEALS THAT IT MAY NEED A REVAMPING. WE NEED TO SET NEW PRIORITIES, DEFINE NEW MISSIONS, AND ARTICULATE NEW AND MORE RELEVANT OBJECTIVES FOR TODAY'S AND TOMORROW'S NEEDS. WE NEED TO SQUEEZE MORE OUT OF EXISTING PROGRAMS AND REDUCE OLD, OUTDATED PROGRAMS TO MAKE ROOM FOR THE NEW.

I BELIEVE THE FOCUS OF THE SYSTEM SHOULD BE REDIRECTED TOWARD THE LOCAL, RATHER THAN NATIONAL, LEVEL BECAUSE STATES AND COUNTIES KNOW THEIR SPECIFIC PROBLEMS BETTER THAN WE AT THE

NATIONAL LEVEL. WE WILL ALL BENEFIT IF THEY HAVE MORE OF A SAY IN WHAT RESEARCH SHOULD BE UNDERTAKEN TO SOLVE THEIR SPECIFIC PROBLEMS.

I HAVE INTRODUCED A BILL THAT EMBRACES THIS CONCEPT. THE BILL, S. 1756, CREATES STATE CENTERED ENTITIES TO EXPLORE SOLUTIONS TO THE PERPLEXING AGRICULTURAL PROBLEMS WE FACE IN EACH STATE.

I HOPE THE SUBCOMMITTEE WILL STUDY THIS BILL AND CONSIDER INCORPORATING ITS LOGIC IN ANY NEW AGRICULTURE RESEARCH BILLS ACTED ON IN THE NEXT CONGRESS. I OFFER THIS BILL, NOT AS A TOTAL SOLUTION, BUT RATHER AS A CONCEPT FOR DISCUSSION, A WAY OF GETTING MORE OUT OF OUR EXISTING RESEARCH DOLLARS.

FOR THOSE MEMBERS WHO THINK THIS BILL HAS MERIT, I WELCOME YOUR COSPONSORSHIP NOW AND AS ORIGINAL COSPONSORS WHEN I RE-INTRODUCE THE BILL IN THE NEXT CONGRESS.

THE PRIMARY PURPOSE OF THE BILL IS TO CREATE STATE "TASK FORCES" TO MAKE THE AGRICULTURE IN EACH STATE MORE COMPETITIVE IN THE INTERNATIONAL MARKETPLACE. I BELIEVE THAT A STATE-CENTERED RESEARCH TASK FORCE, WITH A STRONG PRIVATE SECTOR ADVISORY COMMITTEE, IS THE BEST APPROACH FOR DEVELOPING STRATEGIES THAT WILL KEEP OUR AGRICULTURE VIABLE.

MR. CHAIRMAN, ANYONE WHO HAS TRAVELED THE COUNTRY OVER THE PAST SEVERAL YEARS WILL TELL YOU THAT THE FARM SECTOR HAS FACED SOME VERY TOUGH TIMES. AGRICULTURE HAS CHANGED DRAMATICALLY IN THE PAST FIVE YEARS. IF OUR AGRICULTURE IS TO CONTINUE TO EXPAND, WE MUST REALIZE THESE CHANGES HAVE OCCURRED, AND WE MUST DEVELOP A STRATEGY TO DEAL WITH THESE CHANGES AND PROBLEMS IN THE FUTURE.

THE EXPERTS TELL ME THAT THE U.S. FARM SECTOR FOUND ITSELF IN TROUBLE IN THE PAST BECAUSE OF SEVERAL DIFFERENT FACTORS:

FIRST, A U.S. FARM POLICY WHICH ENCOURAGES OVERPRODUCTION; SECOND, HIGH FOREIGN FARM SUBSIDIES; THIRD, TRADE BARRIERS; FOURTH, THE VALUE OF THE DOLLAR; FIFTH, HIGH ENERGY AND PRODUCTION COSTS; AND, LASTLY, HIGH INTEREST RATES.

IN MY JUDGMENT, IT IS VERY UNLIKELY THAT ANY ONE INDIVIDUAL CAN DESIGN A PERFECT STRATEGY FOR SURVIVING IN THIS EVER-CHANGING AGRICULTURAL ECONOMY. TO DEAL WITH FARM PROBLEMS, SUCH AS THOSE WE HAVE FACED IN THE PAST, WE SHOULD USE A "TASK FORCE" APPROACH THAT HAS THE OBJECTIVES OF:

(1) DEVELOPING NEW STRATEGIES FOR THE EXPANSION OF MARKETS FOR U.S. FARM PRODUCTS;

(2) DESIGNING EFFECTIVE ALTERNATIVES FOR CUTTING PRODUCTION AND OPERATING EXPENSES OF FARMS AND RANCHES;

(3) FACILITATING THE TRANSFER OF NEW DEVELOPMENTS IN BIOTECHNOLOGY TO THE AGRICULTURAL SECTOR; AND

(4) GRADUALLY REDUCING FARM SUBSIDIES.

THEREFORE, I INTRODUCED THIS LEGISLATION TO CREATE A FEDERAL-STATE-INDUSTRY AGRICULTURAL COMPETITIVENESS TASK FORCE IN EACH STATE, TASK FORCES THAT WOULD CONDUCT RESEARCH DIRECTED TOWARD THE SPECIFIC AGRICULTURAL PROBLEMS OF THE STATE. THE RESEARCH WOULD FOCUS ON THOSE FACTORS THAT UNDERCUT THE ABILITY OF THE LOCAL AGRICULTURAL INDUSTRY OF EACH STATE TO COMPETE IN INTERNATIONAL MARKETS, WITH THE GOAL OF DEVELOPING SOLUTIONS TO THOSE PROBLEMS.

THE TASK FORCE IN EACH STATE WOULD BE LOCATED AT THE PRIMARY AGRICULTURAL COLLEGE OR UNIVERSITY OF THE STATE, AS DETERMINED BY THE GOVERNOR.

TO ENSURE THE TASK FORCES DIRECT THEIR WORK TOWARD SPECIFIC STATE PROBLEMS, THEY WILL BE DIRECTED BY A 12-MEMBER INDUSTRY ADVISORY BOARD, APPOINTED BY THE GOVERNOR.

SUBJECT TO APPROPRIATIONS, EACH STATES' TASK FORCE WILL RECEIVE $250,000 PER YEAR IN FEDERAL OPERATING FUNDS, PROVIDING THAT A MATCHING CONTRIBUTION IS MADE BY THE STATE OR PRIVATE SOURCES, OR BOTH. IN ADDITION, SOME $2.5 MILLION PER YEAR IS PROVIDED FOR REGIONAL AND NATIONAL COORDINATION OF THE STATE TASK FORCES.

MY BILL PROVIDES THAT REGIONAL COORDINATION WILL BE ADMINISTERED THROUGH EXISTING AGRICULTURAL EXPERIMENT STATIONS. NATIONAL COORDINATION WILL BE ADMINISTERED THROUGH THE

COOPERATIVE STATE RESEARCH SERVICE (CSRS). THE BILL PROVIDES A FIVE YEAR AUTHORIZATION SUNSET FOR THE TASK FORCES.

MR. CHAIRMAN, I ASK UNANIMOUS CONSENT THAT A DETAILED PAPER ON THE TASK FORCE CONCEPT, "A POSITIVE APPROACH TO THE AMERICAN FARM PROBLEM" BY DR. GERALD THOMAS, BE INSERTED IN THE RECORD AT END OF MY STATEMENT.

DR. THOMAS IS THE PRESIDENT EMERITUS OF NEW MEXICO STATE UNIVERSITY. HE IS A MAN WITH VAST KNOWLEDGE, INTEREST, AND GENUINE CONCERN ABOUT AGRICULTURAL RESEARCH. I RECOMMEND HIS EXCELLENT ANALYSIS TO ALL MY COLLEAGUES AND HOPE THEY WILL SUPPORT THIS CONCEPT, WHICH IS INCORPORATED IN S. 1756.

MR. CHAIRMAN, THANK YOU FOR ALLOWING ME TO SHARE MY THOUGHTS WITH YOUR SUBCOMMITTEE.

A Positive Approach to the American Farm Problem

Gerald W. Thomas

In many respects, American agriculture is in more trouble today than during the great Depression of the thirties. Unless a positive approach to these farm problems is designed promptly, we are in danger of further loss of family farms, substantial reduction in agribusiness and more serious adverse impacts on our rural communities. In addition, a significant tax-payer backlash is developing due to the high level of farm subsidies. (President Reagan's new budget would reduce the level of subsidies from over $26 billion to 21-23 billion--still too high to be tolerated by the average American.)

The agricultural situation has changed so dramatically in the last 5 years that even the experts are confused. Production increases have caused turmoil in international markets and shaken American agriculture at the roots.

--India, once thought to be the world's worst basket case has doubled wheat productions since 1970 and increased rice production by 30 percent.

--Bangledesh, and Indonesia are reportedly self sufficient in food grains.

--Japan, Taiwan, and the Philippines are coping with rice surpluses.

--The EEC (European Economic Community), now the heaviest subsidized agricultural economy in the world, has moved into U.S. food markets--especially since the Soviet Grain embargo.

--The PRC (Peoples Republic of China) with over one billion mouths to feed has increased food output by an unprecedented 40% in less than 5 years.

--And, while many areas of Africa still face critical hunger problems, it is the food surplus world-wide that is the current driving force in both U.S. and international agricultural policy development.

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*President Emeritus, New Mexico State University

Remember the Paddock Brother's Book, "Famine-1975"?; The World Food Conference in Rome in 1974 following the drought of the 1970's?; The Global 2000 Report?; and, many other books and depressing statements about the world's ability to feed itself? I added my own statements to this list of bad forecasts, including the statement "If the Pessimists aren't happy now, chances are they never will be!" Well this situation has changed! And, unless American agriculture can adjust to these changes, we all stand to lose.

What were the circumstances which produced this American farm disaster?

--The rising value of the dollar. The dollar rose 80 percent from 1980-1985 and then fell 70 percent (now about 20 percent above the 1980 level).

--High energy and production costs at the farm level (particularly for irrigated agriculture).

--High interest rates (changing too late for many).

--U.S. farm policies which encouraged fence to fence cultivation and built in false concepts of production costs.

--High subsidies for farmers in the EEC and some other competitor nations.

--Critical trade barriers

In addition to these "circumstances", we saw rapid adoption of some new technologies in foreign countries because these countries finally discovered the importance of providing "an incentive to produce" at the farm level.

What part did the farmers play in this scenario?

--We responded to government programs which provided incentives to break out more land and produce and produce.

--We borrowed on overvalued land--overvalued in most cases because of urban development, tax policies, and farm programs.

--We overmechanized on our own farms, buying expensive equipment which sat idle much of the year--instead of contracting for services. We did not know the real costs of production in relation to market prices.

--We listened to our bankers who said we had plenty of collateral to support that loan for a new tractor or next year's seed and fertilizers. Now the banks in the breadbasket of America are in trouble (375 failures in the last five years-mostly in central U.S.).

--And now, the Farm Credit System has asked for a multi-billion dollar bailout. The financial community has not yet adjusted to all of the reverberations of the producers problems.

Yes, we can, and should blame ourselves as well as the circumstances.

Where were the universities and the USDA when this trouble started to develop? Why didn't our friends, the economists, tell us we were headed for disaster? I live in the University environment. I've been surrounded by economists and I did not see the early warning signs. I was in the cockpit, but I did not see any red lights flash as the plane stalled. Oh, sure, I read about high land values, high interest rates, and some costs of production, but, I did not read any straight forward statements that said "we are in trouble." Someone should have told us 'If you continue in the direction you are going, you are liable to end up where you are headed!"

What, then, are the strategies for survival in this new global economy? First, we must recognize that we live in a rapidly changing, complicated, interdependent world. As Ed Schuh, with the World Bank said recently, "Our economy is subjected to international forces beyond the reach of domestic policies." Richard Madden, Chief Executive Officer of the Potlatch Corp. stated it this way in a distinguished lecture at the University of Idaho:

> "Many American industries have functioned in relative isolation. It can be quite a shock to learn that companies in other countries can deal with the new competitive realities not only better than you can, but also deal with them that way in your own backyard".

During the past 6 years, I have had the opportunity to serve on the Dallas Federal Reserve Bank Board, El Paso Branch. This exposure has provided new insights into our own monetary policy and some of our interactions with foreign countries. Needless to say, I am a strong supporter of the present Federal Reserve System policies.

--I watched the "Fed" manipulate monetary policies to reduce inflation.

--I supported the Federal Reserve reductions in the discount rate to bring interest rates within reason.

--I believe Chairman Paul Volcker is right that our most critical problems are the Federal deficit (a fiscal policy issue) and the trade deficit (a complicated international issue).

In recent testimony before a committee of the U.S. House of Representatives, Chairman Volcker reiterated his concern about the serious nature of the trade balance and our increasing international debt. He said, "the active but scatter-gun approach to protectionism is not the answer." Over 300 bills have been introduced in Congress in the last year to restrict imports. Volcker said:

> "I hope we are fully aware of the risks (in protectionism). The results would be no better than in the 1930's; then, one protectionist measure bred others, and world trade and economic activity were depressed together. Our effort, instead of retreat, must be directed toward opening other markets, and toward assuring (that) trade can proceed on fair and reciprocal terms. This philosophy drove our negotiating efforts at the GATT Conference at Punta Del Este".

I was pleased to see that Secretary of Agriculture Lyng was among the participants at the GATT meetings and that much emphasis was placed upon trying to get the EEC to reduce farm subsidies.

A Task Force Approach

Since no individual can design the best strategies for survival in the new and complicated world, I have a proposal to combine our talents to design strategies for survival.

This is a recommendation for the creation of a Research and Development Task Force in each state focused on three major objectives:

(1) The development of new strategies to improve markets for American farm products.

(2) The design of effective alternatives for cost cutting on farms and ranches to ensure our ability to compete in national and international markets.

(3) The eventual reduction of the multi-billion dollar cost of farm programs.

More specifically, this proposal calls for an amendment to the Farm Bill to allocate a part of the multi-billion dollar subsidies to create a joint state/federal/private industry research and development Task Force in each state. My proposal would be to transfer about $15 million to this fund (a rounding error in the Farm Bill) and allocate $250,000 to each state's major agricultural college. Each state could access this fund only if they matched the $250,000 from state funds. Likewise, a private industry input would be required for two purposes, (1) an advisory committee to keep the research oriented toward marketing problems in each state and (2) a partial funding match to the state/federal program by requiring that all producers who receive over $50,000 (the level under controversy) allocate 10% of the excess over this minimum to this Task Force effort. These large agricultural enterprises have the most to gain from increased markets and the most to lose from a tax-payer backlash.

Regional coordination would come from a small allocaton to the regional efforts such as the existing Agricultural Experiment Station regions (i.e. the Western Region, Great Plains States, etc.). Also, some funds would be set aside for national coordination through USDA. The various State Departments of Agriculture, each with a marketing thrust, would be asked to serve on the advisory committee to the Task Force.

I have purposely proposed that the focus for research be in each state where the scientific teams can be close to the problems. The state focus would also bring a wide variety of new talent to bear on the problem. Scientists in the university environment, somewhat removed from political pressure, should be able to objectively develop and evaluate alternative strategies to keep agriculture viable and competitive.

This Task Force should assemble and analyze our trade relationships with all trading partners, with special attention to "the other 94 countries" where much of our future lies. However, neglect of our neighbors in this hemisphere could lead to trouble. How much do we really know about our relationships with Canada and Mexico?

This Task Force should determine comparative costs of production at home and abroad and help identify our most effective ways to increase efficiency. What new technologies can we utilize?--what labor saving techniques are possible? What is the appropriate level of mechanization? Should we diversify (contrary to the trends which continue toward specialization)? Should we integrate vertically (toward the consumer) to capture more off-farm profits?

This Task Force should outline the strategies to help us influence State Department Policies. Are we pawns or players in the geopolitical chess game?

This Task Force should help us understand National and International Monetary Systems. The move toward protectionism at home is not in our best long-term interest--It builds in false subsidies and false hope. However, in the short run we may have to restrict certain imports if reciprocal relationships are unfair.

This Task Force should be "Market Oriented" and should not neglect the U.S. market which is still our largest present and potential market. We should focus on the American consumer--our changing habits and demands. Our campaign to "eat more beef" or to "wear more cotton" will be effective only if we answer the question "Why? Whats in it for me--the American Consumer?" Of course, we should not hesitate to tell the American consumer that they have been the primary beneficiaries of a productive agriculture and that indirectly, the American consumer has been subsidized to a greater extent than the farmer.

This Task Force should identify the trade barriers and outline a political strategy for change.

This Task Force should provide guidance during the upward trend as well as a downward trend. Dr. Ty Timm, former head of the the Agricultural Economics Department at Texas A&M put it this way: "If your outgo exceeds your income your upkeep will be your downfall."

Lastly, this Task Force should help us establish a balance between production and resource conservation; should help us design into our system "the incentive to conserve" as well as "the incentive to produce." As we re-establish a conservation reserve--let's not allow the next administration to break out these marginal lands as we have done so often in the past? The generations which follow us may well be more concerned about the environmental consequences of our action than the technical questions of production. A balanced approach to production and conservation is both possible and logical.

In summary, there is no turning back. The world has changed and will continue to change. We must learn to compete in this new environment. If we don't manage change, we will be managed by it. "Those Far Away Places with The Strange Sounding Names" will forever be a part of our social, environmental and economic life. Surely, with all our American know-how, we can design strategies for survival in this challenging global economy.

Senator CONRAD. And with that, we will adjourn this hearing. Thank you very much.

[Whereupon, at 12:15 p.m., the joint hearing adjourned, subject to the call of the Chair.]

[Material submitted for inclusion in the record follows:]

New Farm and
Forest Products
Task Force

New Farm and Forest Products

Responses to the Challenges And Opportunities Facing American Agriculture

Executive Summary

***A Report from The New Farm and
Forest Products Task Force to
The Secretary, U.S. Department of
Agriculture, Washington, D.C.***

June 25, 1987

United States
Department of
Agriculture

New Farm and
Forest Products
Task Force

Hamilton Building
Room 635
Washington, D.C.
20250-2200
(202) 535-0962

June 1987

Honorable Richard E. Lyng
Secretary of Agriculture
Washington, D. C. 20250

Dear Mr. Secretary:

When the Secretary's Challenge Forum on New Uses for Farm Products was convened in October 1984, it began a dialogue which subsequently led to the formation of the New Farm and Forest Products Task Force. A collaborative effort between industry, academia and government, our Task Force evolved to address the issues raised at that Forum - issues which we believe are vitally important to the interests of the entire Nation.

Our work over the last two years has convinced us that diversification of agriculture and forestry must become a national priority. Diversification is not only needed to respond to the challenges facing American agriculture, but as a key part of any response to the competitive challenges confronting our entire Nation. As documented in our report, we have found evidence of opportunities for new crops, and other new farm and forest products, to meet real market needs, particularly for industrial uses. Our report therefore proposes specific initiatives to turn such opportunities into realities.

Mr. Secretary, we have recently found our independent results to be remarkably consistent with elements of the President's Competitiveness Initiative launched earlier this year. We also find that 1987 marks notable anniversaries of several significant legislative actions including: the centennial year of the Hatch Act which created the Agricultural Experiment Stations; the 125th anniversary of the founding of your Department; the 25th anniversary of the McIntire-Stennis Act on cooperative forestry research; and, the 10th anniversary of the establishment of an Assistant Secretary for Science and Education. We members of the Task Force hope that our efforts will now serve to catalyze other meaningful actions - ones which will prove to be fitting commemorations to these important precedents.

Respectfully Submitted,

Ronald L. Sampson

New Farm and Forest Products
Task Force

Dr. Ronald L. Sampson, Chairman

Executive Summary

Agriculture, including forestry, is a strategically vital industry for the United States. Not only is food security critical to national security, but the Nation's domestic economy and balance of trade are both highly dependent upon agriculture. As America's largest industry, agriculture must necessarily be a cornerstone for prosperity and international competitiveness.

With its production capacities already underutilized, U.S. agriculture is facing major challenges which portend a chronic crisis state. The causes of this crisis are complex and related to global developments, in addition to long-term domestic policies. However, regardless of cause, **America now has an overconcentration of agricultural production in a relatively few major food and feed crops, - crops for which worldwide production is increasing, and global import markets are shrinking**.

Although the possibility of a regional calamity causing a temporary shortfall in supply always exists, current trends offer little hope for long-term relief. Indeed, deepening problems can be expected in the future, as an increasing number of exporting countries will be competing for shrinking export markets. **These realities pose sobering challenges to U.S. policymakers**, as well as the agricultural industry itself.

The New Farm and Forest Products Task Force was formed to respond to these challenges. A collaborative effort between industry, academia and government, the Task Force evolved in mid-1985 from a previous USDA Challenge Forum to address related issues. Upon formation, the Task Force adopted a mission to define and propose meaningful, actionable initiatives based upon a comprehensive analysis of the situation.

Based on its findings, **the Task Force concluded that diversification of agriculture and forestry must become a national priority**. Indeed, the group concluded that diversification, via both new crops and new uses for existing ones, appears to offer the only alternative which promises to enable both: (1) revitalization of ailing segments of the industries; and (2) realization of the full economic potential which agriculture and forestry hold for the Nation.

Continued efforts to increase efficiency and reduce production costs for current commodities continue to be important; however, in the opinion of the Task Force, at least equal emphasis should be placed on diversification into new crops and other new products. Importantly, the group did find evidence that **significant opportunities exist for new farm and forest products to meet real market needs - particularly in industrial, non-food application areas**.

Based on its findings and conclusions, the New Farm and Forest Products Task Force proposes adoption of the following **national goal**:

To develop and commercialize within 25 years, an array of new farm and forest products, utilizing at least 150 million acres of productive capacity, to meet market needs representing net new demand for agricultural and forestry production.

Such a goal represents the equivalent development of two to three new soybean crops - in about one-half the time the soybean required to rise to its current level of significance. The Task Force estimates that attainment of such a goal today would: generate about 750,000 new jobs; increase farm income by about $30 billion per year; and annually contribute about $100 billion in activity to the Nation's economy.

The Task Force believes the proposed goal is appropriate and attainable. However, success in achieving it will require both technological and institutional innovation. Specifically, **success in large scale diversification of American agriculture will depend upon: (1) adoption of appropriate strategies; and (2) implementation of those strategies through initiatives which provide innovative organizational approaches to overcome past limitations and barriers to success**. Although the quality of public agricultural research has always been quite high, concentration upon production of current commodities, and the lack of mechanisms to ensure commercial relevance and effective technology transfer to industry, have been limitations in the past.

The **diversification strategies** recommended by the Task Force are as follows:

1. Increase national emphasis on, and reallocate existing resources to the development of new farm and forest products;

2. Establish a consensus that diversification of agriculture and forestry should be a national priority, based upon an understanding, across a broad spectrum of society, of the vital contributions that agriculture and forestry make to the health and wealth of the Nation;

3. Establish mechanisms to increase private/public sector collaboration and cooperation in the development of new farm and forest products;

4. Establish mechanisms to facilitate agricultural technology transfer, particularly between the public research and private industrial sectors;

5. Ensure that responsible biotechnological developments can proceed at a rate which retains national leadership in agricultural applications; and

6. Establish an organized program to identify opportunities for encouraging, and reducing barriers to, the development of new farm and forest products.

To implement the strategies and thereby enable attainment of the diversification goal, the New Farm and Forest Products Task Force proposes several specific action steps and initiatives. Each proposal addresses a particular need, and is intended to build upon existing, relevant programs and organizations in both the private and public sectors. However, one of the proposals is considered to be of paramount importance. Specifically, the Task Force considers **the establishment of an independent organizational entity, dedicated to achievement of the diversification goal and provided with adequate resources to attain it, is essential for success**.

In its report, **the Task Force proposes the establishment of the Foundation for New Farm and Forest Products.** The proposed organization would be an autonomous, non-profit corporate entity with a mission to foster and facilitate the development and commercialization of new farm and forest products. As conceptualized, the Foundation would be specifically charged with the responsibility to achieve the diversification goal. Bridging both private and public sectors, **the Foundation would serve as an advocate, catalyst, coordinator, and cooperative funding source for the development of new farm and forest products**.

The Foundation proposal builds upon the results of prior studies and proven organizational models. **A key element of the proposal involves establishment of a trust fund to provide a stable, long term funding source for the needed cooperative private/public sector research programs**. Based on models in other areas of industry and technology, the minimum requirement for such a trust fund would involve a one-time allocation of $100 million - perhaps generated by a single diversion from current commodity support programs. However, although such a minimal program would represent a step in the right direction, it would be inadequate to undertake the enormous and vitally important task of diversifying American agriculture.

To accomplish the diversification goal, **the Task Force recommends that the Foundation be initially funded by proceeds from a $1 billion trust fund invested solely in U.S. Treasury securities**. It is proposed that the fund be established by the sale of $200 million of various commodities held by the Commodity Credit Corporation each year for a five year period. When fully established, income from the trust would annually provide over $75 million as a significant, sustained source of long term "seed and venture capital". Importantly, investments would be directed toward carefully selected, cooperative projects in which private companies and other public organizations are also willing to invest. Such an approach would leverage funding, help ensure market focus, and also enhance cooperation and technology transfer between the public and private sectors. **Foundation investments would be made with provisions to secure royalty returns from successful projects, and the trust fund would ultimately revert back to the Federal Government**.

As detailed in its report, the Task Force proposes several other initiatives related to: (a) commercialization mechanisms for USDA research; (b) multi-disciplinary university research centers relevant to new farm and forest product technologies; (c) international cooperation to develop agricultural sources for industrial raw materials, on a selective basis as mandated by the Critical Agricultural Materials Act of 1984, PL 98284; and (d) task force efforts to address other specific needs.

The New Farm and Forest Products Task Force views its recommendations and proposals as merely starting points - actions to begin the concerted, long-term effort needed to revitalize U.S. agriculture and forestry, and ensure they remain as cornerstones of American competitiveness and prosperity.

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Although encouraged and supported by the U.S. Department of Agriculture, the Task Force was an independent body. Consequently, the group's conclusions and recommendations do not necessarily reflect the views of that Department. Nonetheless, the work of the Task Force could not have been accomplished without the coordination and support of the Department of Agriculture, especially the Office of the Secretary, the Office of the Assistant Secretary for Science and Education, and the Office of Critical Materials. In addition, the counsel and perspectives provided by Dr. Orville G. Bentley, Assistant Secretary for Science and Education, and the Department members of the Task Force Secretariat listed below, were constructive, helpful, and much appreciated.

Similarly, although the findings of the Task Force do not necessarily reflect the views of any particular outside contributor to its work, the individuals listed below as Task Force Associates must be acknowledged. Although not a member of the Task Force, each Associate made substantive contributions to their work. The perspectives the Associates shared, and the time and effort they contributed, were much valued and appreciated.

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(Note: The Secretariat was formed to provide liaison between the Task Force and the Department of Agriculture. With the exception of the Task Force Chairman, each member of the Secretariat was affiliated with the Department.)

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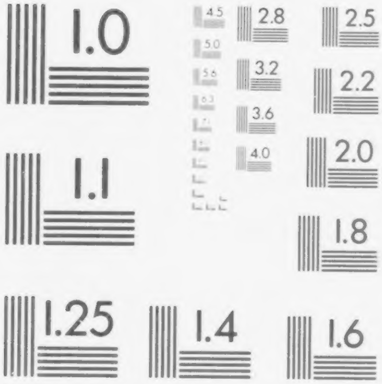
ONE DECIMETER

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)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